VOLUME 83 NO. SA2
APRIL 1957

JOURNAL of the

Sanitary Engineering Division

PROCEEDINGS OF THE

AMERICAN SOCIETY OF CIVIL ENGINEERS

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Journal of the
SANITARY ENGINEERING DIVISION
Proceedings of the American Society of Civil Engineers

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INFILTRATION MEASUREMENTS IN SEWERS OF SMALL SIZE[a]

Robert A. Lincoln,[1] M. ASCE
(Proc. Paper 1203)

SYNOPSIS

A rapid and accurate method of measuring ground water infiltration flows in newly constructed sanitary sewers of small size is discussed. A description is given of the design, fabrication and calibriation of rectangular slit and sutro proportional weirs, developed for use on a certain project, before the project was placed in service to handle sanitary flows. Use of the apparatus in the field is described.

Infiltration in sewers sometimes is a part of litigation pertaining to construction contracts. Success of such litigation can depend upon accurate hydraulic measurements made with calibrated apparatus, the data from which constitutes a part of expert testimony in court by Engineers.

INTRODUCTION

Anyone who has ever been involved in sewer construction, and the measurement of infiltration during the final inspection phase, will probably agree that the process of taking such measurements in small-sized sewers is usually awkward and time-consuming, and that many times obtain results of questionable accuracy. Awkwardness and consumption of time are bad enough, but the matter of accuracy is important; particularly in contract work, where non-acceptance of allegedly completed work results in the withholding of money due a contractor, which in turn may be the cause of litigation. The success of such litigation for either party may hinge upon the accuracy of measurements.

This paper dwells mainly on the development and description of the equipment used, rather than the actual use of such equipment.

Note: Discussion open until September 1, 1957. Paper 1203 is part of the copyrighted Journal of the Sanitary Engineering Division of the American Society of Civil Engineers, Vol. 83, No. SA 2, April, 1957.

a. Presented at Annual Meeting, ASCE, New York, N. Y. October, 1954.

1. Partner, Bogert & Childs, Cons. Engrs., New York, N. Y.

Background

Recently, the firm of Bogert & Childs was retained to make a report on an infiltration matter, and be prepared to testify in court. The infiltration involved a sanitary sewage system in the last stages of construction, consisting of about 30 miles of 8-inch, 10-inch and 15-inch vitrified tile pipe with precast bituminous joints. About half of the 30 miles of pipe had infiltration flows requiring measurement.

In the preparation of data for the report, a large number of accurate flow measurements were required in a short period of time. Realizing that the question of accuracy would be important, and probably the subject of discussion between lawyers and other engineers, it was decided to make the measurements with weirs, which would be accurately fabricated, calibrated and certified to, by a reputable laboratory. It was desirable that the apparatus used be capable of rapid and accurate installation in the sewers to be tested, with a minimum of adjustment.

The use of V-notch weirs was ruled out because it was felt that the weir used would have to produce results more accurate than could be obtained by a V-notch. Accordingly, it was decided to use a rectangular slit weir for the low flows and Sutro proportional weirs for the higher flows. The ranges decided upon and the corresponding weir sizes are given later. Similar equipment and procedure had been used previously with success for the same purpose by the Metropolitan District, Hartford, Connecticut.(1) The Sutro proportional weir had been described in detail some years ago in certain technical publications.(2,3,4)

Arrangements were made to have the weirs made and calibrated in the laboratory of the Research Division of the College of Engineering, New York University. The work came under the supervision of Professor William T. Ingram, M. ASCE.

Requirements

The basic instructions given the N.Y.U. Laboratory in ordering the work were as follows:

1. Design a series of Sutro weirs and/or rectangular slits to cover ranges of flow from 0.1 gallons per minute to 40 gallons per minute.
2. Construct the weir plates from a durable light-weight material that can be accurately machined.
3. Construct a series of weir plate holders of light-weight metal for insertion into 8-inch, 10-inch and 15-inch vitrified tile pipe, upon which the weir plates can be interchangeable.
4. Calibrate the weir plates, with a visible scale on the inside of each plate, to be used with a certified chart reading directly in gallons per minute.

Description

The range of weirs selected for the required flows were as follows:

Weir I - 1/16" wide by 4-1/2" high, slit range - 0.1 gpm to 2 gpm

Weir II - 1/8" by 2" Sutro range - 1 gpm to 15 gpm

Weir III - 1/2" by 3" Sutro range - 10 gpm to 50 gpm

The weirs were fabricated from 3/8" thick transparent Plexiglass with the openings finished on a milling machine. Because of the difficulty in cutting the 1/16" slot for Weir I, the slit was first cut into a 1/32" thick stainless steel plate, and this plate cemented into a recess cut into the Plexiglass. The area around the opening in Weir II and Weir III was milled down so that the thickness of the critical face of the weir opening was 1/16" thick. This was done to eliminate the effect of wall thickness on flow through the weir. A transparent metric scale was cemented to the inside face of each weir plate. Each plate was drilled with a series of holes spaced to fit a pattern of stud bolts on the end plate of the weir plate holder. The plate was fitted to the holder over a rubber gasket and held in place with wing nuts.

The check calculations for Weir I to set up dimensions for fabrications were:

$L = 1/16'' = 0.00521'$ $H = 4\ 1/2'' = 0.375'$

$Q = KLH^{3/2}$ (Francis formula neglecting approach velocity)

$K = 3.33$

$Q = 3.33 \times 0.00521 \times 0.2296 = 1.79$ gpm

$K = 4.38$ (Bazin formula)

$Q = 4.38 \times 0.00521 \times 0.2296 = 2.36$ gpm

The Sutro weirs were designed according to the formulas and design shown on Diagram "A." From this data, tabulations of theoretical dimensions for fabrication were worked out as shown in Tables 1 and 2.

To facilitate the rapid installation of the weirs in the field, a plastic level vial was cemented to the top of each weir plate.

Three weir plate holders were fabricated for insertion into 8-inch, 10-inch and 15-inch pipe, out of 16 gauge sheet metal. A hand opening in the top of each holder permitted the removal of foreign matter. A turnbuckle rod was fastened to the rear of each holder inside the sewer pipe. The outer side of the holder was fitted with a foam rubber strip to insure water-tightness.

The weirs were calibrated in the laboratory by time volume, using a weigh tank and stop watch for Weirs II and III, and a graduated cylinder and stop watch for Weir I. Each weir was calibrated at 10 millimeter intervals.

The actual ranges of the three weirs as calibrated were as follows:

Weir I - 0.15 gpm to 1.75 gpm
Weir II - 1.5 gpm to 13.4 gpm
Weir III - 4.8 gpm to 50 gpm

The calculated values were very close to the values developed by calibration.

FIELD USE

Procedure in the field was simple. The equipment as developed was rapidly and accurately installed and readings quickly made. It was found that a flashlight held in back of the transparent weir plate facilitated the reading of the water level on the plate. Charts were mounted on plywood and covered with transparent plastic. A tabular form was developed showing weir read-

ing, corresponding flow figure taken from the weir chart, time, location, etcetera. Readings were taken in manholes progressing upstream, and, by subtraction, the amount of infiltration was established for each run of sewer, both between manholes and for any street, or series of streets desired. The records were kept in permanent form for future use, if required for court testimony.

REFERENCES

1. Sweeton, Arthur W., 3rd, A.M.ASCE, "Weir Plates Helpful in Sewer Gaging." Civil Engineering, January, 1953.
2. Rettger, E.W., "A Proportional-Flow Weir," Engineering News, June 25, 1914.
3. Pratt, E.A., "Another Proportional-Flow Weir; Sutro Weir," Engineering News, August 27, 1914.
4. Soucek, E., Howe, H.E., and Mavis, F.T., "Sutro Weir Investigations Furnish Discharge Coefficients," Engineering News-Record, November 12, 1936.

$\frac{X}{L} = 1 - \frac{2}{\pi} \tan^{-1} \sqrt{\frac{Y}{a}}$

$K = C a^{\frac{1}{2}} L \sqrt{\frac{a}{a}}$

$Q = K (H - \frac{a}{3})$ (1)

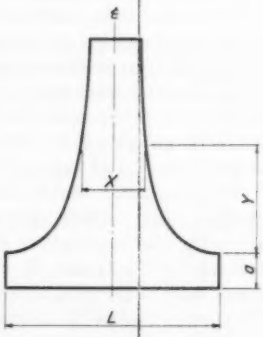
WHEN X = LENGTH OF WEIR OPENING AT HEIGHT a+Y IN FEET.

L = CREST LENGTH IN FEET.

Y = HEIGHT ABOVE TOP OF SLOT TO WIDTH X IN FT.

C = SUTRO WEIR COEFFICIENT VARIES FROM 0.6 TO 0.63

H, a, Q - AS GIVEN IN EQUATION (1) ABOVE.



SUTRO WEIR
DIAGRAM "A"

Fig. 1.

CALCULATED DIMENSIONS

Y/a	Y	X/L	X	Y/a	Y	X/L	X
.1	.0125	.805	1.610	5	.625	.268	.536
.2	.0250	.732	1.464	6	.750	.247	.494
.3	.0375	.681	1.362	7	.875	.230	.460
.4	.0500	.641	1.282	8	1.000	.216	.432
.5	.0625	.608	1.216	9	1.125	.205	.410
.6	.0750	.580	1.160	10	1.250	.195	.390
.7	.0875	.556	1.112	12	1.500	.179	.358
.8	.1000	.536	1.072	14	1.750	.166	.332
.9	.1125	.517	1.032	16	2.000	.156	.312
1.0	.1250	.500	1.000	18	2.250	.147	.294
2.0	.2500	.392	.784	20	2.500	.140	.280
3.0	.3750	.333	.666	25	3.125	.126	.252
4.0	.5000	.295	.590	30	3.750	.115	.230

$a = \frac{1}{8}$" - $L = 2$" - $K = 0.0816$

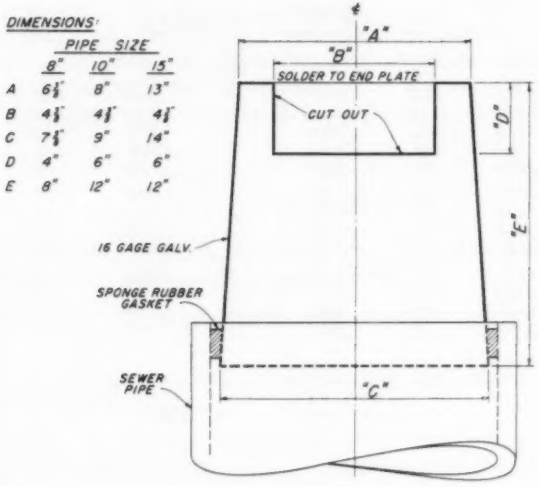
SUTRO WEIR II

Y/a	Y	X/L	X
.1	.05	.805	2.415
.2	.10	.732	2.196
.3	.15	.681	2.043
.4	.20	.641	1.923
.5	.25	.608	1.824
.6	.30	.580	1.740
.7	.35	.556	1.668
.8	.40	.536	1.608
.9	.45	.517	1.551
1.0	.50	.500	1.500
2.0	1.00	.392	1.176
3.0	1.50	.333	.999
4.0	2.00	.295	.885
5.0	2.50	.268	.804
6.0	3.00	.247	.741

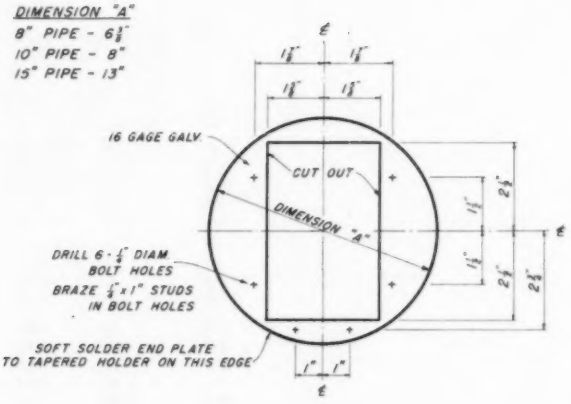
$a = \frac{1}{2}$" - $L = 3$" - $K = 0.245$

SUTRO WEIR III

Fig. 2.



PLAN



DETAIL OF END PLATE

SUTRO WEIR
PLATE HOLDER

Fig. 3.

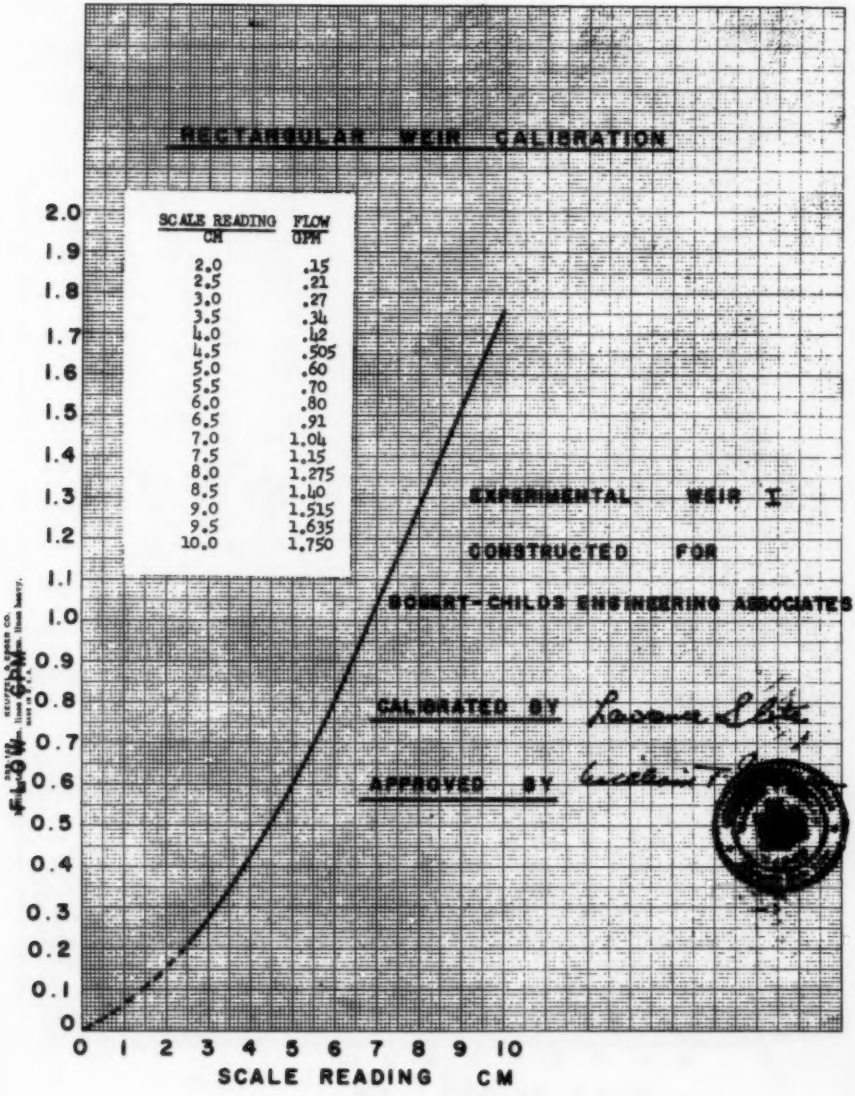

RECTANGULAR WEIR CALIBRATION
SCALE READING CM | FLOW GPM
2.0 .15
2.5 .21
3.0 .27
3.5 .34
4.0 .42
4.5 .505
5.0 .60
5.5 .70
6.0 .80
6.5 .91
7.0 1.04
7.5 1.15
8.0 1.275
8.5 1.40
9.0 1.515
9.5 1.635
10.0 1.750
EXPERIMENTAL WEIR I
CONSTRUCTED FOR
BOBERT-CHILDS ENGINEERING ASSOCIATES
CALIBRATED BY
APPROVED BY
FLOW GPM
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
0 1 2 3 4 5 6 7 8 9 10
SCALE READING CM

Fig. 4.

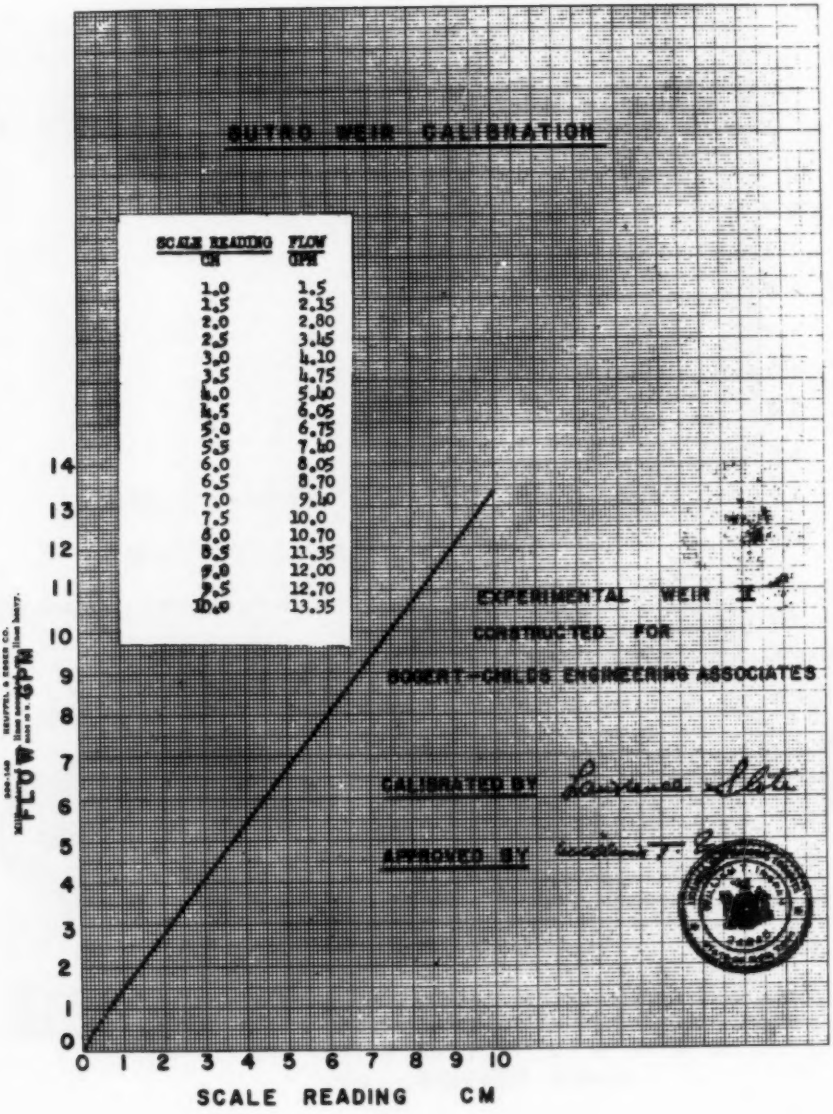

SUTRO WEIR CALIBRATION
SCALE READING CM
FLOW CFM
1.0 1.5
1.5 2.15
2.0 2.80
2.5 3.45
3.0 4.10
3.5 4.75
4.0 5.40
4.5 6.05
5.0 6.75
5.5 7.40
6.0 8.05
6.5 8.70
7.0 9.40
7.5 10.0
8.0 10.70
8.5 11.35
9.0 12.00
9.5 12.70
10.0 13.35
EXPERIMENTAL WEIR II
CONSTRUCTED FOR
ROBERT-CHILDS ENGINEERING ASSOCIATES
CALIBRATED BY
APPROVED BY
0 1 2 3 4 5 6 7 8 9 10
SCALE READING CM

Fig. 5.

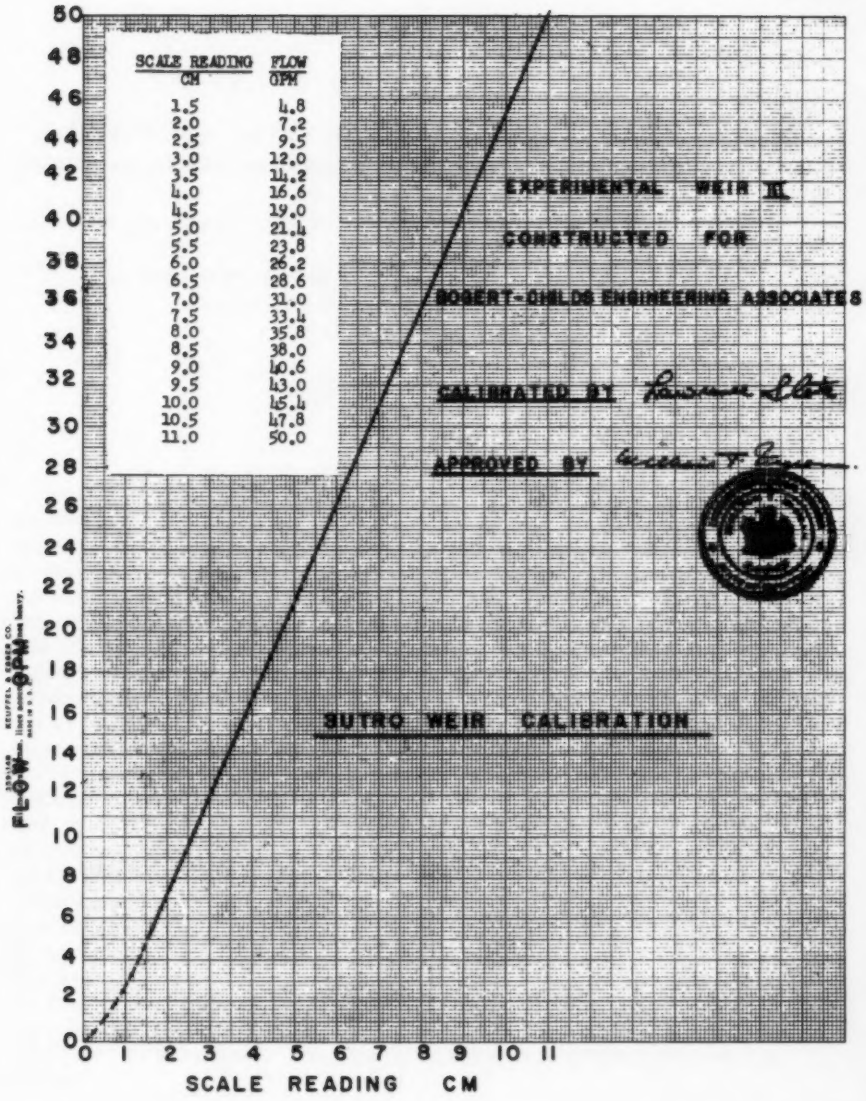

SCALE READING CM | FLOW GPM
1.5 | 4.8
2.0 | 7.2
2.5 | 9.5
3.0 | 12.0
3.5 | 14.2
4.0 | 16.6
4.5 | 19.0
5.0 | 21.4
5.5 | 23.8
6.0 | 26.2
6.5 | 28.6
7.0 | 31.0
7.5 | 33.4
8.0 | 35.8
8.5 | 38.0
9.0 | 40.6
9.5 | 43.0
10.0 | 45.4
10.5 | 47.8
11.0 | 50.0
EXPERIMENTAL WEIR III
CONSTRUCTED FOR
ROBERT-OHLDS ENGINEERING ASSOCIATES
CALIBRATED BY
APPROVED BY
SUTRO WEIR CALIBRATION
FLOW GPM
SCALE READING CM
0 1 2 3 4 5 6 7 8 9 10 11
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50

Fig. 6.

Journal of the
SANITARY ENGINEERING DIVISION
Proceedings of the American Society of Civil Engineers

SANITARY ENGINEERING EDUCATION: ITS EVOLUTION

by Harvey F. Ludwig,* M. ASCE, Edmund J. Laubusch,**
and Erman A. Pearson,*** A.M. ASCE
(Proc. Paper 1218)

FOREWORD

The rapidly changing technology since World War II has created many new problems for the sanitary engineer. It has become readily apparent that the educational training of the sanitary engineer is deficient for solving these problems. Over the past year there has been increased attention as to what the education of sanitary engineers should be. The Publications Committee has collected seven papers dealing with the education of sanitary engineers and has tied them together as a Symposium. As in any symposium where the papers were not prepared for a single presentation there is a certain overlap of ideas. This overlap is most significant as it represents the trend of thinking by various individuals who are most interested in the problem of sanitary engineering education.

This Symposium starts with a discussion of the evolution of sanitary engineering education; where it started, how it has progressed up to today and what it will be tomorrow. This is followed by a discussion of the general educational requirements for sanitary engineers and the needs in the Southeast. The specific requirements for specialties in industrial hygiene, air pollution and industrial wastes are outlined. The Symposium ends with a description of the ICA assistance to sanitary engineering education in Peru. It is hoped that this symposium will stimulate interest in the problem of education for sanitary engineers. The diverse nature of the field has created a considerable problem which will not be solved by any one person or any one committee but only by the combined efforts of all sanitary engineers interested in their field. The papers included in this Symposium are as follows:

Note: Discussion open until September 1, 1957. Paper 1218 is part of the copyrighted Journal of the Sanitary Engineering Division of the American Society of Civil Engineers, Vol. 83, No. SA 2, April, 1957.

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***Associate Prof. of San. Eng., Univ. of California, Berkeley, Calif.

1. Paper 1218 Sanitary Engineering Education: Its Evolution by Harvey F. Ludwig, Edmund J. Laubuash and Erman A. Pearson.
2. Paper 1219 Sanitary Engineering Education: General Requirements by Daniel A. Okun.
3. Paper 1220 Sanitary Engineering Education: Needs in the Southeast by John E. Kiker, Jr.
4. Paper 1221 Sanitary Engineering Education: Industrial Hygiene Engineering by Alvin F. Meyer, Jr.
5. Paper 1222 Sanitary Engineering Education: Air Pollution Engineering by Harvey F. Ludwig and Frank A. Butrico.
6. Paper 1223 Sanitary Engineering Education: Industrial Waste Engineering by Ross E. McKinney.
7. Paper 1224 Sanitary Engineering Education: ICA Assistance in Peru by Marvin L. Granstrom.

ABSTRACT

Sanitary Engineering education has been undergoing a steady evolution over the past 65 years to meet the demands of a changing technology. The present trend is towards graduate level training with uniform standards of education becoming a necessity.

With every index of growth in the United States pointing to a steady increase in population and continued expansion of industry, sanitary engineering will become more and more significant in its role of making it possible for people to enjoy the benefits of modern technology while giving minimum personal attention to protecting themselves from its hazards. The extent to which sanitary engineers now entering the profession will be able to accept the new challenges accompanying this Nation's industrial development will depend, in considerable measure, on the intellectual stimulation and motivation they receive in college.

Scope of Sanitary Engineering

Sanitary engineering may be defined as the application of engineering principles to man's environment—to water, air, food, shelter, and working areas—for the protection and promotion of the public health.(1) As a profession, it dates back only to just before the turn of the century and, moreover, the nature of its work has been continually changing since that time. Sanitary engineering has been, and still is, a profession in transition and evolution, and any appraisal of its past, present, and future must begin with an evaluation of this changing status.

For many years, the Public Health Service, United States Department of Health, Education, and Welfare, has conducted studies of sanitary engineering education, and has published periodic reports of the numbers of individuals who have received specialized training in this field.(2,3) These accumulated data are briefly summarized in this paper. Data on undergraduate sanitary

engineering education generally refer, somewhat arbitrarily, to a minimum exposure of about 15 semester units of sanitary engineering subjects, either in a separate curriculum or as an option or electives in a civil engineering program. No attempt is made by the authors to define what might be considered as representing the desirable or even minimum scope of sanitary engineering curricula.

Percentage-wise, as shown in Figure 1, sanitary engineering comprises a very small fraction of total engineering enrollment; this is indicative of its highly specialized status. During the period 1949-1955, of all engineering degrees conferred, an average of less than 10 per 1000 were to students who had sanitary engineering training.

Importance-wise, we in sanitary engineering like to think of our profession as one of the bulwarks of modern community living. Through the furnishing and protection of community water and food supplies; collection and safe disposal of wastes discharged to land, water, and air; control of insect and rodent vectors of disease; control of radioactive wastes and radiation hazards; and other measures, the sanitary engineer makes it possible for people and industry to concentrate in heavily populated metropolitan areas without deterioration of the environment and the public health.

The Past

Sanitary engineering as a science had its start in the 1890's, in working with the water phase of the environment, i.e., water supply and treatment, and sewage collection, treatment and disposal.(4) Beginning attention was also given at that time to the application of bacteriological principles in the control of food-borne diseases. Control of insects and rodents of public-health importance was also recognized as an important problem. With attention to water as the focus of interest, the early organization of sanitary engineering teaching was undertaken within curricula in civil engineering, supplemented with special attention to chemistry and microbiology. Prominent examples were the schools of sanitary engineering established by William Thompson Sedgwick at the Massachusetts Institute of Technology, by Harold Babbitt at the University of Illinois, and by Charles Gilman Hyde at the University of California.

A second era in the development of sanitary engineering, which took place over the 20-year period 1925-45, represented an intensification of earlier efforts. This included advanced water-treatment technology; advanced sewage-treatment technology, including reclamation of valuable organic components; and attention to industrial wastes as a separate problem of major importance. Also emphasized were improvements in food processing to provide "built-in" protection against contamination, and attention to housing and to working places as environmental factors definitely impinging on health. Characteristic of this, as well as of previous periods, was recognition of the significance of economics as a basic factor in the design and development of sanitary engineering facilities. During this period, the number of schools offering sanitary engineering training increased from 13 to 33, approximately three-fourths the number in business today. As shown in Figure 2, the number of sanitary engineering degrees conferred, particularly at the bachelor's and master's levels, increased accordingly. The impact of World War II brought full fruition to this phase of sanitary engineering.

The demands for engineers with sanitary engineering education increased to such an extent that they created a need for graduate curricula in sanitary engineering—generally leading to the master's degree—for engineers not possessing a specialized sanitary engineering undergraduate education. The graduate program established by Gordon M. Fair at Harvard University met this need, and it has had a major influence on sanitary engineering education in the United States.

Another development of the past decade has been the trend towards agreement on terminology. In recent years, sanitary engineers have attempted to develop an all-inclusive and completely satisfactory term for describing the broad area of engineering activity in environmental health. The term environmental health, environmental sanitation, environmental engineering, public-health engineering, and others, have been tried. Each of these had had its test, and now the definite trend is back toward recognition of the term sanitary engineering as the most satisfactory one to mean the application of engineering principles to control of the environment in the interest of public health.

The Present

A third era in the evolution of sanitary engineering—the present one—represents a blossoming out of the profession to include serious attention to all phases of men's environment.(5) A major factor in this era is a rate of technological advance unprecedented in history, and an associated acceleration in production and use of commodities. For example, a sevenfold increase in industrial production since 1900, half of which has occurred since 1940, has resulted in increased urbanization—and the attendant problems of metropolitan areas. The emerging atomic age and the development of nuclear energy for power production and other beneficial industrial uses further compound the problem. A crucial factor in the application of nuclear energy to peaceful purposes will be the ability of engineers and scientists to devise economical means for safe treatment and disposal of radioactive wastes and control of radiation hazards. An additional byproduct of modern metropolitan living is the area of community air-pollution control. As in the case of stream pollution, the engineering problem is to permit waste discharges to the atmosphere within limits of its natural capacity to absorb them without significant detriment to the air resource. The current position in this field compares with the status of water pollution control about 1925, except that the problems in air pollution may be technically even more complex and difficult.

Even a cursory review of the evolution of sanitary engineering training indicates that relatively little has been accomplished toward the development of undergraduate curricula (or options and electives) sufficiently comprehensive to enable the average graduate—without subsequent training—to solve these environmental health problems of today. A high degree of undergraduate specialization leading perhaps to a bachelor's degree in sanitary engineering, in fact, would not be to the best interests of either the student engineer or to the sanitary engineering profession. First, because the varied functions of a sanitary engineer necessitate education even more extensive than that ordinarily acquired through basic engineering training, such as chemistry, biology, mathematics, physics, and other supporting disciplines. And second, if he is to fulfill his responsibility to society, he must have a thorough indoctrination in the humanistic-social subjects.

More and more it is recognized—as the numbers of new, specialized, technical fields increase by leaps and bounds, and moreover, do not "fit" into the traditional concept of divisions of engineering education—that it is futile to expect to wedge into an already packed undergraduate curriculum any significant degree of specialized knowledge; also, that it is better to limit undergraduate work to basic training which permits the individual to specialize later in his chosen branch of engineering, as needed in the pursuit of his career. A most important concept in the undergraduate training is to impress upon the student the rapidity of change in technology, so that he will not feel bound to any particular pursuit, but, rather, free to undertake any which suits his particular talents. The graduate embarking on a professional career should be at ease in an era in which new knowledge is being discovered at an amazing rate, and new problems of ever-increasing complexity are being encountered.

In response to the changing situation, schools of sanitary engineering have shifted emphasis from undergraduate to graduate areas, a change also in keeping with the trend throughout engineering toward less and less undergraduate specialization. This adjustment is, of course, simply in tune with the times. A review of Figure 3 confirms this shift in emphasis in sanitary engineering education.

The Future

Another factor in the shifting nature of sanitary engineering education has been a broadening of the basic engineering groups from which sanitary engineers are drawn. As already noted, most sanitary engineers have been civil engineers with special training; today, with the field of work expanded into all phases of environment, engineers with basic training in chemical and mechanical engineering have backgrounds as applicable as civil engineers to such environmental health fields as industrial hygiene and air pollution control. The point of emphasis is that sanitary engineering today involves competencies in various disciplines and in varying degrees. And what might be considered adequate in scope and breadth for one sanitary engineer may be totally inadequate for another. The situation since World War II, therefore, has been shaping up toward agreement that the minimum academic education for the sanitary engineer of the future will comprise basic undergraduate engineering; generally civil, chemical, or mechanical, supplemented by not less than a year of specialized graduate study leading to the master's degree. However, it is clearly recognized that sanitary engineers expecting to achieve positions of professional prominence and/or requiring high-level technical competence should seriously consider education at the doctorate level. Such educational qualifications are especially important for engineers interested in careers in research and teaching; for the practicing sanitary engineer, the additional training is needed to equip him to analyze and resolve the scientific problems confronting him, many of which will involve virgin areas of applied science. A further factor is, the inevitable trend towards establishment of the doctorate degree as the basic criterion for delineation of professionally qualified persons throughout the scientific and engineering fields.

The Changing Status

Administrative problems are being encountered in adjusting to this transition. Most established graduate curricula in sanitary engineering are geared

to the traditional civil engineering basis, dealing with water and sewage works. As pointed out in a recent paper on graduate study in air pollution,(6) a need exists for administrative mechanics in universities which would permit the graduate student with a thorough engineering background to pursue a curriculum made up of appropriate courses in the various departments involved—in this case, chemical engineering, chemistry, physics, meteorology, industrial hygiene, etc. The particular program would be based on the appropriate core of fundamental sanitary engineering courses which would also serve as the integrating medium for the related scientific fields. Several prominent educational institutions have recently established, or are in the process of establishing, graduate programs in engineering science or "science-engineering" which would permit sufficient latitude in the graduate curricula to encompass all areas of the basic and applied sciences, as well as engineering required for the technically competent sanitary engineer. Such programs will also permit graduate study in the sanitary engineering field for biologists, chemists, and physicists, with a basic core engineering course requirement to qualify the individual as an engineer.

The main reason for this is the large gap in basic scientific knowledge needed for the solution of the complex problems which the sanitary engineer is expected to solve. A major step-up is needed in the national research effort to produce this knowledge, but meanwhile the sanitary engineer must often proceed with the application of controls ahead of guiding research. Nevertheless, the situation is encouraging in the increasing public awareness of the problem. For example, water-pollution control is being recognized as a key measure in the solution of the Nation's growing water resources problem, and air-pollution control is a "must" if metropolitan areas are to continue to maintain a healthful and respectable atmosphere. In fact, it appears that the extent to which health hazards in the environment are controlled is likely to be a critical governing factor in the rate of total technological advancement.

Another serious problem faced by established schools of sanitary engineering derives from the fact that sanitary engineering teaching, because of the extensive laboratory facilities required and the relatively small enrollment, has been more expensive to administer than most other types of engineering training. Since World War II, industry has contributed substantially by assisting in the financial underwriting of many university graduate engineering operations, with respect to providing fellowships for students and to providing assistance for instructors and faculty. Advanced academic training is now being provided sanitary engineering personnel who have demonstrated ability and who are equipped to cope with the vigor of intensive graduate-level training to better prepare them to solve the technological complexes of these times. Similar assistance, which must come primarily from government, is essential to sanitary engineering if the profession is to survive the very competitive manpower situation which lies ahead. In the State health agencies, for example, of the 30% of all sanitary engineers who have had at least one year of graduate training, over 90% have received such training at State expense. At the Federal level this pattern also is being established. In addition, the Public Health Service, through research grants, fellowship grants, and training grants, is now undertaking a significant program along these lines.

In addition to sponsoring formal graduate-level education to promising engineers, both industry and government have embarked on a program of inservice training adapted to their peculiar needs. Notable in this regard is the Public Health Service short courses in various fields of sanitary engineering which are conducted primarily through the Training Branch of the Robert A. Taft Sanitary Engineering Center in Cincinnati. These courses, which are now attended by about 1600 engineers and scientists each year, provide inservice-type training or instruction in new areas not yet included in most university curricula. The appointment this year of a National Advisory Committee for the Center, made up primarily of sanitary engineering professors, is intended, among other things, to insure maximum collaboration between the universities and the Center in meeting the Nation's training needs in this field. Similarly, summertime and sabbatical assignments for university professors in operations and research sanitary engineering programs of the Public Health Service have tended to encourage communication and understanding between the academic and the actual areas of application. Liaison of this kind is essential if the profession is to achieve the stature and recognition we believe it merits. Notable progress has been made through this means in the development of sanitary engineering curricula tailored to meet contemporary needs at such places as Harvard, in the field of water resources and pollution abatement, and at MIT, the University of Florida, the University of California, and others, in the air pollution control and industrial hygiene.

SUMMARY

Recapitulating, it is evident that the trend in sanitary engineering education is toward decreasing emphasis in specialized training in undergraduate curricula, and increasing emphasis on and need for graduate specialization, especially the doctorate degree. While sanitary engineering training received at the undergraduate level is, and will continue to represent, the entree by which a number of successful practicing sanitary engineers enter the profession, it is believed that undergraduate programs serve principally to orient the prospective graduate student in the dynamic nature, the opportunities, and the rewards of a sanitary engineering career. Being so indoctrinated, the product of the undergraduate educational system we support will be flexible and versatile enough to specialize, and to absorb and apply graduate level knowledge with satisfaction and ease.

As indicated earlier, sanitary engineering has never been a stabilized profession; only now is it on the threshold of achieving uniformity in standards. The establishment of recognized standards for graduate study in sanitary engineering—the definition of the academic foundation for sanitary engineering—will, of course, greatly assist in helping the profession to attract and hold top-caliber engineers.

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Figure I. SANITARY ENGINEERING DEGREES PER THOUSAND ENGINEERING, DEGREES 1949-1955

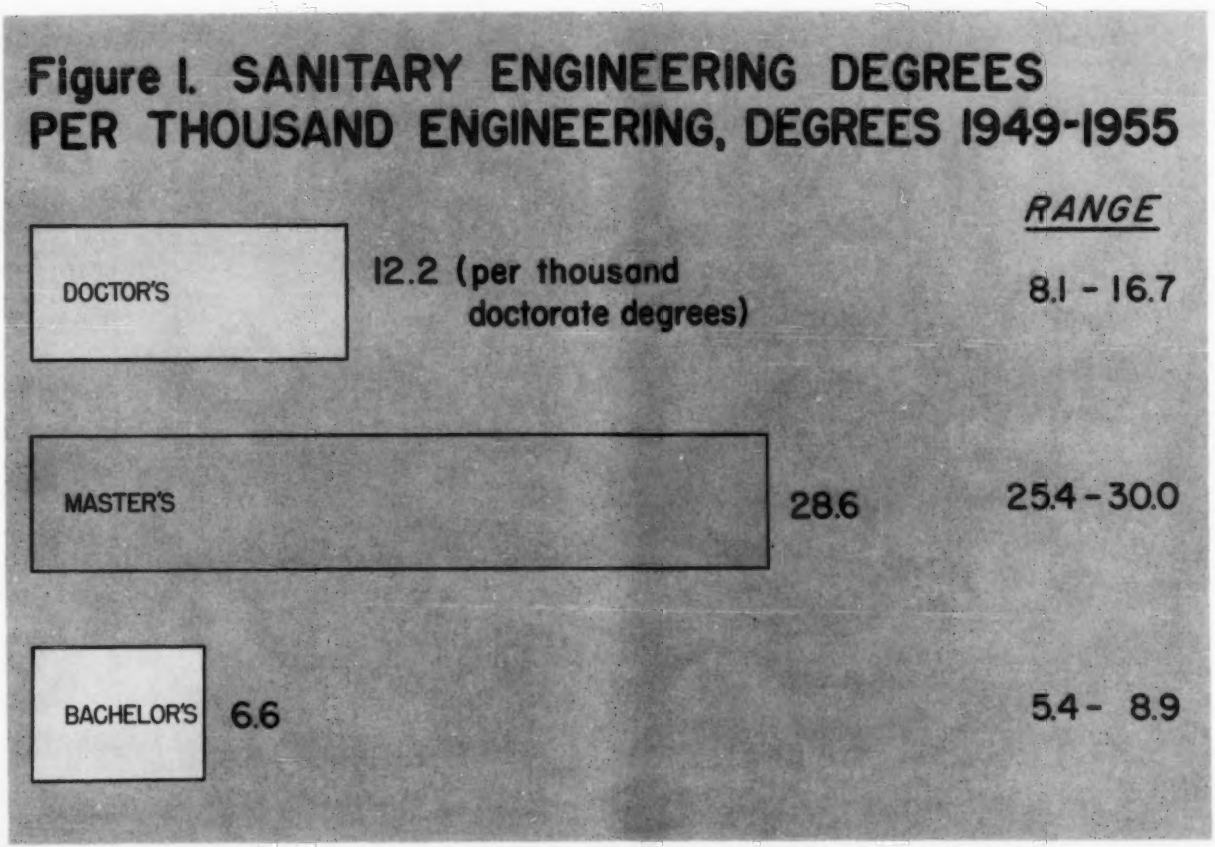
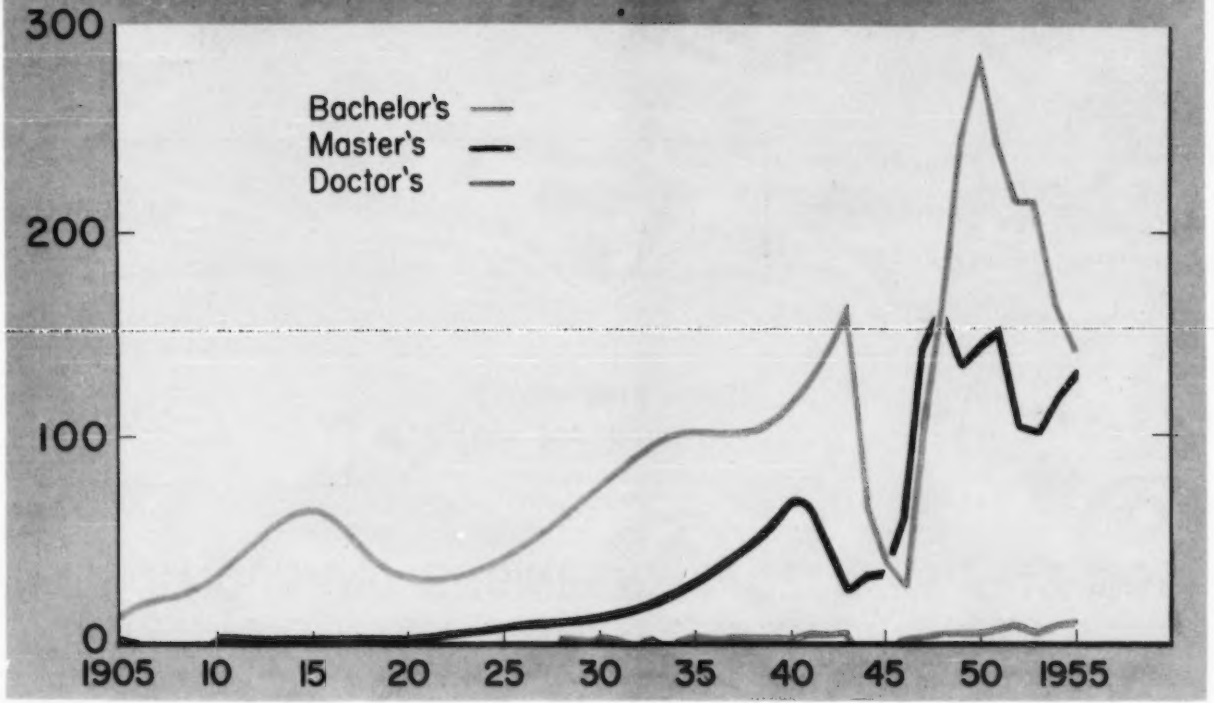


Figure 2. UNDERGRADUATE AND GRADUATE SANITARY ENGINEERING DEGREES 1905-1955



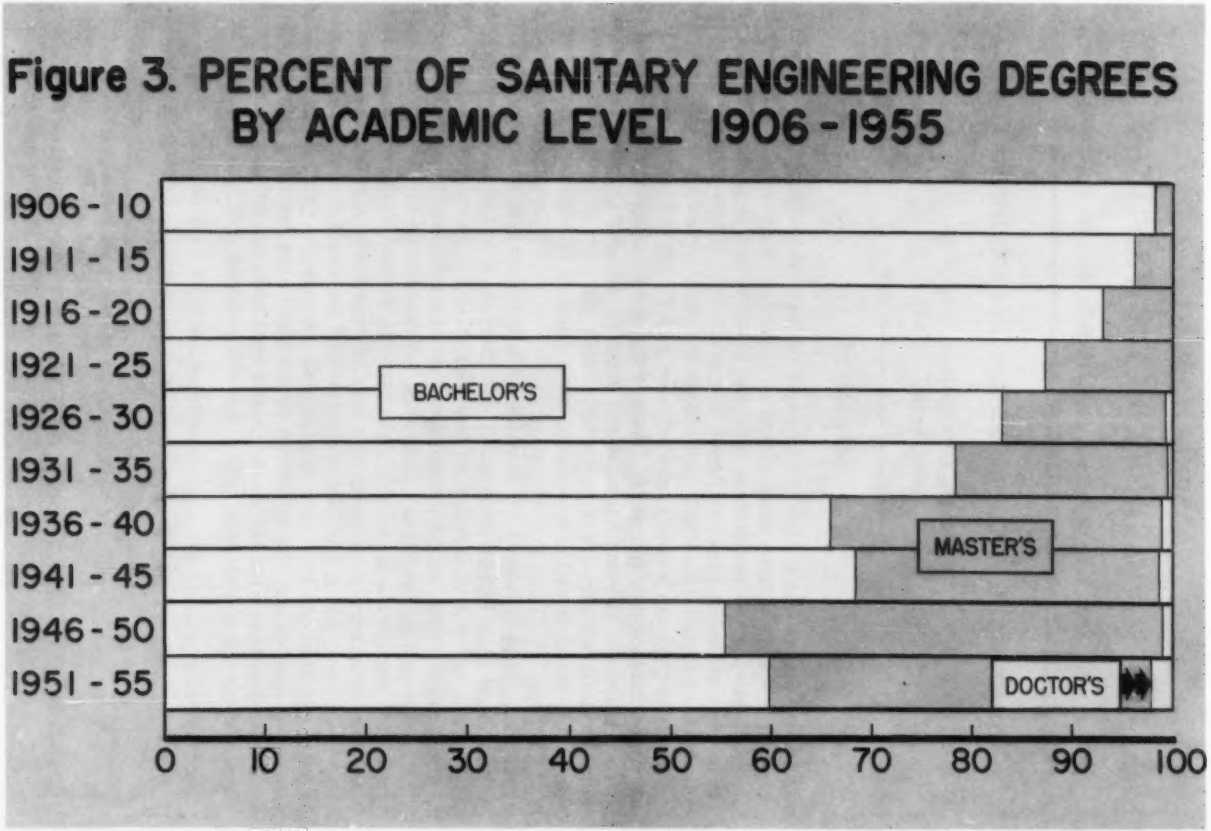


Figure 3. PERCENT OF SANITARY ENGINEERING DEGREES BY ACADEMIC LEVEL 1906-1955
1906 - 10
1911 - 15
1916 - 20
1921 - 25
1926 - 30
1931 - 35
1936 - 40
1941 - 45
1946 - 50
1951 - 55
BACHELOR'S
MASTER'S
DOCTOR'S
0
10
20
30
40
50
60
70
80
90
100

Paper 1219 SA 2

Journal of the
SANITARY ENGINEERING DIVISION
Proceedings of the American Society of Civil Engineers

SANITARY ENGINEERING EDUCATION: GENERAL REQUIREMENTS*

by Daniel A. Okun,** A.M. ASCE
(Proc. Paper 1219)

FOREWORD

The rapidly changing technology since World War II has created many new problems for the sanitary engineer. It has become readily apparent that the educational training of the sanitary engineer is deficient for solving these problems. Over the past year there has been increased attention as to what the education of sanitary engineers should be. The Publications Committee has collected seven papers dealing with the education of sanitary engineers and has tied them together as a Symposium. As in any symposium where the papers were not prepared for a single presentation there is a certain overlap of ideas. This overlap is most significant as it represents the trend of thinking by various individuals who are most interested in the problem of sanitary engineering education.

This Symposium starts with a discussion of the evolution of sanitary engineering education; where it started, how it has progressed up to today and what it will be tomorrow. This is followed by a discussion of the general educational requirements for sanitary engineers and the needs in the Southeast. The specific requirements for specialties in industrial hygiene, air pollution and industrial wastes are outlined. The Symposium ends with a description of the ICA assistance to sanitary engineering education in Peru. It is hoped that this symposium will stimulate interest in the problem of education for sanitary engineers. The diverse nature of the field has created a considerable problem which will not be solved by any one person or any one committee but only by the combined efforts of all sanitary engineers interested in their field. The papers included in this Symposium are as follows:

1. Paper 1218 Sanitary Engineering Education - Its Evolution by Harvey F. Ludwig, Edmund J. Laubusch and Erman A. Pearson.

Note: Discussion open until September 1, 1957. Paper 1219 is part of the copyrighted Journal of the Sanitary Engineering Division of the American Society of Civil Engineers, Vol. 83, No. SA 2, April, 1957.

*Presented to the Sanitary Engineering Division of the American Society of Civil Engineering, at its Jackson, Mississippi meeting, on February 18, 1957.

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2. Paper 1219 Sanitary Engineering Education - General Requirements by Daniel A. Okun.
3. Paper 1220 Sanitary Engineering Education - Needs in the Southeast by John E. Kiker, Jr.
4. Paper 1221 Sanitary Engineering Education - Industrial Hygiene Engineering by Alvin F. Meyer, Jr.
5. Paper 1222 Sanitary Engineering Education - Air Pollution Engineering by Harvey F. Ludwig and Frank A. Butrico.
6. Paper 1223 Sanitary Engineering Education - Industrial Waste Engineering by Ross E. McKinney.
7. Paper 1224 Sanitary Engineering Education - ICA Assistance in Peru by Marvin L. Granstrom.

SYNOPSIS

Sanitary engineers must be educated to meet modern challenges. The many areas of science preparation, and the desirability of development through a major branch of engineering, preferably civil engineering, require that sanitary engineering education be on a graduate basis, with faculty strong in the sciences. Sanitary engineers on undergraduate engineering faculties have an opportunity to recruit to the field.

The sanitary engineering profession is facing many new challenges today. The growing complexity of our social organization has created problems which sanitary engineers, in concert with other professionals in the planning and health fields, are expected to help solve. In his turn, the educator of sanitary engineers is expected to provide leadership and stimulation to young engineers in their endeavors in new and uncharted areas. In assessing the role of the educator, the following questions need to be answered, each in turn.

Why are sanitary engineers educated?
What areas of knowledge are required?
Who is prepared to educate in these areas?
How can this education be best organized?
Who can guide young men into sanitary engineering?

Why are Sanitary Engineers Educated?

Perhaps the most obvious reason for educating sanitary engineers, and certainly the reason which tends to dominate our educational activity, is the preparation of engineers for day-to-day activities in connection with health agencies, municipal facilities, consulting engineering organizations, industry, equipment manufacturers and research and educational institutions.

Attempts have been made to enlist the ideas of such "users" of sanitary engineers in preparing curricula. These attempts have, in general, been futile. The needs of the users vary considerably and in many instances they have concluded that they can train men for their own organizations. Does this mean that the educational institutions have failed? Hardly.

It is not the function of educational institutions to "train" men for positions. By definition, to train is "to form by instruction, discipline, drill, etc." Training can be given, and given efficiently, "in service." On the other hand, to educate is "to develop and cultivate mentally. . . ." This is the task for the educational institutions.

The goals of engineering education have been stated by the American Society of Engineering Education's Committee on Evaluation of Engineering Education:

> "The first objective, the technical goal of engineering education, is. . . preparation for the performance (or full knowledge) of the functions of analysis and creative design. . . . The second objective, the broad social goal of engineering education, includes the development of leadership. . . and the general education of the individual. . . ."

Thus, professional engineering education should fit a man for life and in addition should equip him for creativity in any position in his professional field. What is, then, the professional field of the sanitary engineer?

The specific areas which define the field of the sanitary engineer have been incorporated in the definition of the term "Sanitary Engineer" approved by the Committee on Sanitary Engineering and Environment of the National Academy of Sciences - National Research Council in 1954 and adopted by the American Sanitary Engineering Intersociety Board in its certification procedures:

a. Water supply, treatment and distribution,
b. The collection, treatment and disposal of community wastes, viz., sanitary sewage, industrial wastes and refuse, including salvage and reclamation of useful components of such wastes,
c. The control of pollution of surface waterways and ground waters and of surface and subsurface soils,
d. Milk and food sanitation,
e. Housing and institutional sanitation,
f. Insect and vermin control or eradication,
g. Rural, camp and recreation park sanitation,
h. The control of atmospheric pollution and air quality and of light, noise, vibration and toxic materials,
i. The prevention of radiation exposure,
j. Other fields that have as their major objective the control of environmental factors affecting health.

What is common among these apparently diverse fields? Can a sanitary engineer be expected to be prepared in all of these fields? The answer lies in the last item: ". . . the control of environmental factors affecting health." The sanitary engineer is expected to help solve all problems created by environmental factors, some of which may not have existed when he was receiving his professional education. Entirely new factors are continually evolving and lie over the horizon.

If the sanitary engineer is to be educated for his role and for life, he must be armed with the tools for his work in all the fields enumerated above and for the fields yet unborn. The practices in the various fields do not permit any one man to become expert in very many of these areas. Also, practices change rapidly, and it is wasteful to teach practices in fields in which a man

might not be active until such times as the practices will have changed. The basic sciences and engineering principles, however, offer a more solid foundation for future endeavors in sanitary engineering.

What Areas of Knowledge are Required?

It may seem that the list of basic sciences presented below is far too long. To the apprehensive we might cite Glenn T. Seaborg, Nobel prize-winning discoverer of plutonium, who stated that "Science should be a part of the repertory of a cultured man." How much more should this be true of the engineer, who applies science for the benefit of man, and of the sanitary engineer who applies science for the health of man. The sanitary engineer who aspires to both the technical and social goals set for him by society must be nurtured on a diet of science. More than any other branch of engineering, sanitary engineering rests on a base of all the natural sciences. Geyer said at the V Congress of AIDIS (Association Interamericana de Ingenieria Sanitaria) in Lima, Peru, last year, "It's a field in which the student need never worry about learning things which will be of no use in his professional career."

There has been a growing recognition of the place of the humanities and social sciences in the education of all engineers. Uniquely, the sanitary engineer is obliged to promote works and programs and to "sell" his ideas to civic leaders. He is often in a position of authority in groups of non-engineers. The implements of persuasion must be in his armament and of these a working knowledge of our language is mandatory and an understanding of personal and community relationships is helpful.

There has been much written concerning curricula for sanitary engineers. It is not the purpose of this paper to discuss specific course offerings and credit allowances, but rather to present the areas of basic knowledge required by sanitary engineers.

Mathematics

An engineer should acquire his mathematics through differential equations early in his education in order to permit physics and chemistry to be learned in terms of the mathematics upon which they are based. Therefore it is desirable that an engineer's education be initiated in high school. In sanitary engineering fields, the gap between cause and effect is often very great and correlation can only be established by applying sound statistical principles, so that study in statistics is desirable.

Physical Sciences

Any engineer must have course work in fluid and solid mechanics, thermodynamics, electricity and nuclear physics. The applications of these sciences in all fields of sanitary engineering are too obvious to need elaboration. In addition the civil and sanitary engineer needs preparation in soil mechanics, geology and hydrology.

Chemistry

New knowledge in the chemistry of chlorine solutions has modified our disinfection practices. The continual evolution of new, and there is something

new under the sun, synthetic chemicals has given the sanitary engineer new tools as well as new headaches. In order to understand the principles which apply in almost every area of sanitary engineering, the engineer should have preparation in inorganic chemistry, including qualitative and quantitative analysis, organic chemistry and physical and colloidal chemistry. Since much of his work involves very dilute concentrations of substances in water, food and air, the sanitary engineer needs special work in analytical methods including instrumental analysis and radiochemistry. While sanitary engineers do not need the breadth or depth in chemistry that chemists require, they should have a working comprehension of the fundamentals applicable to sanitary engineering problems.

Biological Sciences

Control of the environment for the protection of health involves a fundamental understanding of the physiology of living organisms—from the smallest to the human. Bacteriology and virology, parasitology, entomology, hydrobiology, physiology, epidemiology and ecology are all necessary studies for the sanitary engineer. An understanding of the stabilization of wastes, whether in natural or in artificial environment, involves an appreciation of biochemistry. The effect of radiation exposure requires a knowledge of health physics. Again, the breadth and depth in these sciences need not be what biologists require but special courses can be designed to include the areas pertinent to sanitary engineering.

Engineering Sciences

Sanitary engineering historically has developed as a field of specialization for the civil engineer. The American Society of Civil Engineers is the only one of the founder societies represented on the Joint Committee for the Advancement of Sanitary Engineering and its concern with technical activities in the sanitary engineering field is evidenced by its strong Sanitary Engineering Division.

Therefore, while it is recognized that chemical and mechanical engineers do become sanitary engineers, our discussion will be limited to the education of the civil engineers for sanitary engineering. The applied sciences and engineering subjects generally required for all civil engineers include surveying, electric power, hydro and steam power, machine design, structural design, hydraulics, water supply and sewerage.

In addition the "compleat" sanitary engineer should have courses in the following areas: water and sewage treatment, industrial water supply and waste treatment, stream sanitation, atmospheric pollution control, industrial hygiene, housing, insect and rodent control, milk and food control and public health administration.

Who is Prepared to Educate in These Areas?

Techniques of education are sterile if they involve only transmission of facts. The best teachers create a desire for knowledge, an urge to search beyond the borders of assembled data, and bring together isolated facts for the purpose of explaining observed phenomena. Few of us remember facts that we learned in school or college, but we do remember our inspiring teachers.

This paper does not propose a panacea for the harried dean or department head. He has difficulties finding a qualified teacher, let alone an inspired one. We do offer, however, that the most stimulating teachers are those most interested in their subjects—and those most interested are those engaged in continuous study or research or other activity in their fields.

A university is not a collection of courses, facts, libraries or laboratories —it is a collection of individuals each dedicated to a specific field of learning and each confident that his specialty is of prime significance in the curriculum. (He is also certain that this conviction is not always shared by the administration.)

Many subjects have been listed and with the high degree of specialization today, we could use a great number of different teachers. However, this is neither reasonable nor desirable. While a biology major would expect to have a different specialist teach each of the courses listed under the biological sciences, the biology for the sanitary engineer might be handled by one man—but he should be a biologist with a deep interest in one of the areas of specialty significant to sanitary engineering.

Biology is one of the sciences inadequately covered in most of our engineering institutions. One of the ways in which this deficiency could be met, if time were available in the curriculum, is by sending the students over to the biology department. The difficulty with this approach is evident and plagues many of our existing offerings. Courses given in another department of a university are not directed to the specific needs of the sanitary engineers. Many of these courses are designed for students who will then take other, more advanced, courses later. For the engineer this is often his first and last contact with the subject. Most engineering institutions require one full year of inorganic chemistry but no organic, physical, colloidal or analytical chemistry.

Sanitary engineers should be taught by chemists but they should be sanitary chemists; by biologists, but they should be biologists with interests in the sanitary field. Courses can then be designed efficiently, and be made more stimulating to the student because the material could be related to sanitary engineering works.

It is true that not many sanitary chemists or biologists are available. However, recruiting them from among graduates with advanced degrees in chemistry and biology is our responsibility. They are needed not only for teaching but for much of the research work in sanitary engineering. Most advances in sanitary engineering are based on new chemical and biological processes. In the horse-and-buggy days of sanitary engineering an engineer could make like a chemist without getting too badly hurt. Today we are remiss if chemists and biologists and their many new techniques are not used in the solution of sanitary engineering problems. The determination of contaminants in water, food and air and studies in their removal require instruments which engineers had better leave to chemists to use, although engineers should understand their areas of application and their limitations.

A graduate department of sanitary engineering is a fine place for the education of sanitary chemists and biologists. At the University of North Carolina we are trying to recruit young chemists and biologists and encourage them to do graduate and research work in sanitary science. Many other opportunities are available in addition to teaching and research, i.e., in stream pollution control, water and waste treatment, particularly in industry, air pollution

control, food processing and sanitation, etc. The judicious employment of qualified sanitary chemists and biologists can help relieve the shortage of sanitary engineers.

To sum up, chemists and biologists and physicists and others are needed to educate sanitary engineers—and it is desirable that they be concerned with the role their sciences can play in the control of the environment. The problem then remains as to how they can be integrated into a sanitary engineering educational program.

How Can this Education be Organized?

Significant professional advantages accrue to the sanitary engineer by virtue of development through and association with one of the major branches of engineering, and particularly with its societies. There is not at present, nor is there likely to be, nor should there be, a separate professional association for sanitary engineers. By requiring professional registration prior to certification the Intersociety Board acknowledges the unique qualifications for sanitary engineers over and above those for civil, chemical or mechanical engineers. Granting the necessity for professional competence in one of the major branches of engineering, most generally civil engineering, and recognizing

a. that education in the humanities and the natural and social sciences is necessary for all engineers and in general should be expanded if engineers are to be prepared for more than only technical roles in society, and

b. that the rapid growth in knowledge in the sciences has increased the amount of material which all engineers must get in school and has led to increasing emphasis on science and less on engineering applications in undergraduate engineering education, and

c. that sanitary engineers must get considerable additional scientific preparation beyond that of other civil engineers,

it becomes inescapable that sanitary engineering education cannot readily be fitted into a four-year undergraduate program.

All engineers, and particularly sanitary engineers because of their close association with the medical profession, have been seeking professional recognition. This is not primarily for self-sustenance, but rather to permit greater service to society. The requirement of graduate education could do much to establish the professional status of sanitary engineers. The American Sanitary Engineering Intersociety Board should eventually require graduate education for sanitary engineers and might then introduce some type of accreditation of sanitary engineering educational programs.

To those who feel that more than four years is expensive, it should be pointed out that a properly educated sanitary engineer can make contributions which more than warrant the additional cost. The value of graduate sanitary engineering education has been recognized by federal, state, local and private organizations who have supported graduate programs financially. Today any qualified engineering school graduate can get financial support for graduate sanitary engineering education.

Some institutions offer a five-year program in sanitary engineering and these may meet the content requirement. However, they are difficult to administer where other engineering programs in the same institution require four years for the Bachelor's degree or where neighboring institutions offer

four-year programs. Also it is rare that a student is able to select a specialty such as sanitary engineering early in his educational program.

The greatest promise for sanitary engineering education lies in the conventional undergraduate civil engineering program, rich in humanities and basic and engineering sciences but with few engineering practice electives, followed by graduate study leading to a Master's degree in sanitary engineering where additional of the basic sciences, particularly chemistry and biology, and sanitary engineering courses are taken. Ludwig, Laubusch and Pearson, in their excellent paper on the evolution of sanitary engineering education presented last year at the Knoxville meeting of the American Society of Civil Engineers, point out that there has been a shift in emphasis from undergraduate to graduate education in sanitary engineering, "a change in keeping with the trend throughout engineering toward less and less specialization."

A nine-month graduate sanitary engineering program is intensive. To avoid waste of time, most of the courses, particularly the required courses in sanitary chemistry and biology, should be taught by sanitary chemists and biologists within the faculty of sanitary engineering. Where other departments of the university can be incorporated into the program they must agree to special offerings for the sanitary engineering graduate students.

If chemists and biologists are to be encouraged to come to a faculty of sanitary engineering, an active research program is necessary. The research program not only makes for interesting and stimulating teachers, but it also enriches education. While the Master's program generally does not permit the student time for independent research, an appreciation of research developed by contact with those engaged in it will imbue the engineers with a respect for the methodology and the personnel involved. It might even induce one or two to undertake careers in research.

There are more than 50 institutions authorized to give Master's degrees in sanitary engineering. However, only ten account for 70% of the degrees given in the last ten years (1946-55). Some ten other institutions have fairly strong programs, but the remaining do not have the breadth of faculty necessary for proper graduate sanitary engineering education and do not have students regularly enrolled. It would appear sound for the profession to encourage strong graduate programs, with faculties comprising sanitary engineers, chemists, biologists and other specialists, and to encourage the research that such a faculty could perform.

Who Can Guide Young Men into Sanitary Engineering?

If sanitary engineering education is to be restricted to graduate study, the possibilities of recruitment to the field are diminished. It is rather easier to direct an undergraduate to an option while he is already enrolled in school than to persuade him to undertake additional education after completing four arduous years. And we must recruit. Every week there are requests for sanitary engineers for leadership positions. The shortage is real, as anyone can testify who stalks convention corridors in search of personnel.

Here rests the unique opportunity for the sanitary engineering professor in the undergraduate program. He teaches several courses to the civil engineering students, generally hydraulics, water supply, sewerage and the like, and he also may teach the chemical and mechanical engineering students. He alone can kindle an interest in sanitary engineering in students. He alone

is in a position to select those students who by aptitude, scholarship, and ability to get along with others might make the best candidates for the sanitary engineering profession.

Class after class of civil engineers have graduated without one man turning to sanitary engineering because there was no sanitary engineer on the faculty.

On the other hand, there have been many instances where a sanitary engineering professor on the civil engineering faculty has been able to guide young men into taking the electives in sanitary engineering and has encouraged them to undertake graduate work. A word of recommendation from the professor to one of the strong graduate faculties can assure the promising student financial help.

CONCLUSION

1. Sanitary engineers should be "educated" to give creative leadership in the control of our environment for the protection of health.
2. The great and constantly increasing body of knowledge required by the sanitary engineer and the desirability of his association with one of the major branches of engineering, generally civil engineering, require that sanitary engineering education be given on a graduate basis.
3. Bachelor's degree programs in civil, chemical or mechanical engineering should be rich in sciences and the humanities, with little emphasis on courses devoted to engineering practice. Those who elect to pursue careers in sanitary engineering would then take a Master's degree program in sanitary engineering. This graduate program should add courses in sciences, particularly in sanitary chemistry and biology, and in application of all sciences to the solution of problems of environmental control.
4. Graduate sanitary engineering programs should be strong in faculty and resources for research. The best teachers of sanitary engineers include scientists who are engaged in study and research on chemical and biological and physical problems in the sanitary engineering field.
5. Sanitary engineering professors in undergraduate engineering programs have an opportunity and a responsibility to recruit young engineers for sanitary engineering. One method is by guiding them to graduate programs in sanitary engineering for which funds are available from many sources.

Journal of the
SANITARY ENGINEERING DIVISION
Proceedings of the American Society of Civil Engineers

SANITARY ENGINEERING EDUCATION: NEEDS IN THE SOUTHEAST*

John E. Kiker, Jr.,[1] M. ASCE
(Proc. Paper 1220)

FOREWORD

The rapidly changing technology since World War II has created many new problems for the sanitary engineer. It has become readily apparent that the educational training of the sanitary engineer is deficient for solving these problems. Over the past year there has been increased attention as to what the education of sanitary engineers should be. The Publications Committee has collected seven papers dealing with the education of sanitary engineers and has tied them together as a Symposium. As in any symposium where the papers were not prepared for a single presentation there is a certain overlap of ideas. This overlap is most significant as it represents the trend of thinking by various individuals who are most interested in the problem of sanitary engineering education.

This Symposium starts with a discussion of the evolution of sanitary engineering education; where it started, how it has progressed up to today and what it will be tomorrow. This is followed by a discussion of the general educational requirements for sanitary engineers and the needs in the Southeast. The specific requirements for specialties in industrial hygiene, air pollution and industrial wastes are outlined. The Symposium ends with a description of the ICA assistance to sanitary engineering education in Peru. It is hoped that this symposium will stimulate interest in the problem of education for sanitary engineers. The diverse nature of the field has created a considerable problem which will not be solved by any one person or any one committee but only by the combined efforts of all sanitary engineers interested in their field. The papers included in this Symposium are as follows:

1) Paper 1218 Sanitary Engineering Education—Its Evolution by Harvey F. Ludwig, Edmund J. Laubusch and Erman A. Pearson.
2) Paper 1219 Sanitary Engineering Education—General Requirements by Daniel A. Okun.

Note: Discussion open until September 1, 1957. Paper 1220 is part of the copyrighted Journal of the Sanitary Engineering Division of the American Society of Civil Engineers, Vol. 83, No. SA 2, April, 1957.

* Presented before the Sanitary Engineering Division at ASCE Summer Meeting, Knoxville, Tennessee, June 8, 1956.

1. Prof. of Civ. Eng., Univ. of Florida, Gainesville, Fla.

3) Paper 1220 Sanitary Engineering Education—Needs in the Southeast by John E. Kiker, Jr.
4) Paper 1221 Sanitary Engineering Education—Industrial Hygiene Engineering by Alvin F. Meyer, Jr.
5) Paper 1222 Sanitary Engineering Education—Air Pollution Engineering by Harvey F. Ludwig and Frank A. Butrico.
6) Paper 1223 Sanitary Engineering Education—Industrial Waste Engineering by Ross E. McKinney.
7) Paper 1224 Sanitary Engineering Education—ICA Assistance in Peru by Marvin L. Granstrom.

SYNOPSIS

The sanitary engineering needs have been very great in the Southeastern section of the United States. In order to meet these needs there has been an increase in the sanitary engineering education in the colleges and universities in this area. With the increased education has come means of attracting young students through various financial methods of support while attending school.

"Rich as is the heritage of the sanitary engineer who during the past century has made life more secure in these United States, his greatest opportunity and challenge lie before him as he extends his skill and knowledge to the peoples of the world. No service performed by any branch of engineering is in greater demand or has more direct application to the improvement of the international good will than that which is within the realm of the sanitary engineer."

The foregoing is quoted from a report of the American Society of Civil Engineers Committee for the Advancement of Sanitary Engineering, at the Centennial of Engineering which was held at Chicago in September, 1952.[2]

It represents the thesis on which some sanitary engineering educators have attempted to sell the sanitary engineering profession to students; that is, this has been the approach to students in at least one section of the Southeast. For about five years, from 1947 to 1952, it seemed to be enough. But it has not been enough during the last four years because the current enrollment of sanitary engineering students is only a fraction of what it was in 1952. Thus, the greatest need at present is more sanitary engineering students, and sanitary engineering educators must find a way to attract them. How may this be done? A few basic facts should be considered before answering the question.

Today's engineering student is not content with a mere opportunity to perform a service. He is more interested in returns which can be measured in dollars and cents. Most sanitary engineers have been recruited from civil engineering students. Just a few years ago, there were more students taking civil engineering than any other branch of engineering. Recently, however,

2. Transactions of the ASCE, Vol. CT, 1953, p. 665.

they have been decreasing both in number and in per cent. One reason for this is because civil engineering has become less lucrative, relatively, than the other branches of engineering. This is shown in the following table.

TABLE I. MEDIAN EARNINGS IN 1952

According to Branch of Engineering[3]

Branch	Earnings
Civil	$7,390
Electrical	7,940
Mechanical	8,250
Chemical	8,910
Mining & Metallurgical	8,730
Other	8,600

A result has been fewer civil and sanitary engineering graduates as previously explained. The actual figures for the University of Florida are given in Tables II and III.

It is believed that the salaries of engineers in the various branches are influenced by the basic principles of supply and demand. Although there has been an unprecedented demand for sanitary engineers in recent years, there has also been an unprecedented demand for engineers in other branches, including civil. It does not appear that these demands are likely to decrease in the near future. It is hoped, certainly, that they will not decrease. Nor does it appear that the salaries of electrical, mechanical, chemical, aeronautical, industrial, and other engineers are likely to decrease as compared with those of civil and sanitary engineers. Indeed, there may be even further proportionate increases, because these "other" engineers work mostly in industry while the numbers of civil and sanitary engineers are proportionately greater in governmental agencies where salaries are much lower than those offered by industry.[3]

Undergraduate Scholarships

Now for the answer to the question as to how students may be attracted to sanitary engineering. Based on the experience of others, it appears that this may be done by offering scholarships for undergraduate study in sanitary engineering. Legislation to authorize 5,000 Federal scholarships annually for engineering and science study has already been introduced by Senator Earle C. Clements of Kentucky, majority whip of the Senate.[4] Senator Clements said his bill was based on his experience as governor of Kentucky when he initiated a program of financial assistance to deserving students in

3. Professional Engineers' Income and Salary Survey, National Society of Professional Engineers, 2029 K Street, N.W., Washington 6, D.C.
4. Legislative Bulletin, Vol. XI, No. 4, May 14, 1956, National Society of Professional Engineers, 2029 K Street, N.W., Washington 6, D.C.

engineering and science to help meet a shortage situation in the highway department. In explaining the shortage, he said that one of the reasons which "stands out with appalling clarity" is the fact that startling numbers of bright boys and girls do not go on to college but that many of them would pursue such studies if they had financial assistance. The bill (S. 3748—Senate Committee on Labor and Public Welfare) provides for student compensation of $100 per month during the course of the study. A unique feature of the proposal is that the student would have to render four years' service with the federal government after graduation, if a position in the federal service is offered. It is recognized that there are disadvantages as well as advantages in this feature, but the proposed bill has a great deal of merit and it represents a logical approach in the solution of a serious problem. It also indicates a need for someone in power to champion the cause of sanitary engineering just as Senator Clements has done for highway engineering.

There is no need, of course, to remind this audience of the analogy of the situations with regard to highway and sanitary engineers. The structural engineers who comprise the other major group of civil engineers are currently having an easier time in obtaining lucrative positions, largely in industry. That is one reason why most civil engineering students today are electing the structural route.

In summary, scholarships are needed to stimulate undergraduate study in sanitary engineering, and to provide manpower needed by state boards of health and others for basic sanitary engineering positions which may not require graduate work. They are needed also to provide an important nucleus of students capable of pursuing graduate work.

Graduate Scholarships

Undergraduate sanitary engineering curricula are so crowded with fundamentals that little specialization is possible. They provide only the basic essentials for proper orientation. A year or more of graduate work is advisable for the study of applications of the fundamental principles learned as an undergraduate. The master's degree in sanitary engineering is as common now as the baccalaureate degree was several decades ago. Employers now generally recognize the value of graduate work. This is usually reflected in higher rates of pay for persons who hold graduate degrees.

Work beyond the master's degree is important in many cases, particularly when the student wishes to avail himself of ever increasing opportunities in research and teaching. It is already true that much of the fundamental research in sanitary engineering is being contributed by persons with the Doctor's degree. In many institutions the doctorate has also become a "union card" for opportunities in teaching. Studies leading to the doctorate are especially needed in some of the new and expanding fields of sanitary engineering, such as air pollution control, and radiological health including the control of radiation hazards.

Scholarships for graduate work have been available but the stipends have been generally inadequate to attract students who are married and have family responsibilities. More and better graduate scholarships are needed.

Research Grants

Few educational institutions are provided with the funds required for satisfactory programs of fundamental and applied research. Sanitary engineering is still a relatively new field in which a tremendous amount of research is urgently needed. It is needed in connection with the protection of our dwindling water resources; the development of methods of controlling air pollution; and in the control of radiation hazards. These are just a few of the most important areas of sanitary engineering where research is needed.

The research grants program that is now being conducted by the National Institutes of Health, in the Sanitary Engineering and Occupational Health Study Section, illustrates what can be done to stimulate valuable research by making funds for the purpose available to educational institutions. These N.I.H. grants have literally made sanitary engineering research programs at some educational institutions and have saved them at others. But they have not gone far enough. More grants are needed. And they should be of a continuing nature.

In order to improve and expand the N.I.H. research program some concerted efforts may be required of a number of people, including engineers in general and sanitary engineering educators in particular. A mere look at the graphs showing research grants in the past will prove the point. The amounts expended for research on such problems as cancer, poliomyelitis, muscular dystrophy and heart disease show impressive increases almost every year; but the amounts allotted annually for basic sanitary engineering research have remained almost constant and are represented by a graph that is virtually horizontal. Research in all of these areas is important but sanitary engineering research is equally important and should be recognized as such. The main reason why it has not been so recognized is because it has not been supported adequately by sanitary engineers outside of the Public Health Service. Research in the other areas has received vigorous, organized support from a number of groups which take advantage of almost every opportunity to make themselves heard by the congressional representatives responsible for the needed appropriations. The sanitary engineering profession must do the same if it is to make similar progress. Efforts should also be made to obtain more equitable recognition and treatment from such groups as the Commonwealth Fund, the Rockefeller Foundation, Ford Foundation, National Science Foundation, Kellogg Foundation, Carnegie Foundation, Office of Naval Research and the Department of Defense.

Summer Employment

Another item on which sanitary engineering education needs additional support in the southeast is concerned with the provision of summer employment for sanitary engineering students. Other engineering students have opportunities for summer employment under the sponsorship of highway departments, contractors' associations, and many industries. Some state health departments also provide attractive summer employment for engineers, and this often influences the choice of a career by a young engineering student.

In many northern states, sanitary engineering activities are heaviest during the summer months when the resort areas are open and the schools closed. Health departments in some of these states provide the summer

employment that is needed. Such opportunities are rather rare in states like Florida where resort areas are open the year around, but they are badly needed. They should provide minimum monthly salaries of at least $200 for students who have completed their freshman year, $250 for sophomores, $300 for juniors, and $350 for students having completed four years of a five-year program. Lower summer employment rates would have an adverse effect, because they would not compare favorably with salaries obtained by students in other branches of engineering. They are already considerably lower than the wages received by students who participate in the Florida Industries Cooperative Plan. (The figures are considered quite in line with minimum year around salaries of $400 a month for graduates, $450 a month for holders of the master's degree, and $550+ for those with the doctorate and no experience.)

Recognition of Chemical and Mechanical Engineering

It is generally agreed that none of the undergraduate curricula for civil, chemical, or mechanical engineering provide adequate basic training in the fundamentals needed by the sanitary engineer. For the design and construction of waterworks and sewerage systems, a civil engineering curriculum provides the most desirable path. For other types of sanitary engineering work including the operation of water purification and sewage treatment plants, chemical engineering is more suitable. Yet the designing engineer must also know the details of operation in order to lay out a plant that will perform at maximum efficiency.

Both chemical engineering and mechanical engineering are suitable foundations for industrial hygiene and air pollution control.[5] However, none of the traditional undergraduate engineering curricula provide sufficient background in bacteriology and public health and these subjects have to be made up when an engineering student undertakes graduate work in sanitary engineering. According to a recent A.P.H.A. committee report, the University of North Carolina is the only institution in the southeast which does not require that such studies be taken as foundation courses without graduate credit unless the student has taken civil engineering as an undergraduate.[6] Apparently, no other university in the southeast will accept undergraduate degrees in chemical and mechanical engineering as meeting the usual entrance requirements for graduate work in sanitary engineering. Harvard, on the other hand, accepts both degrees as meeting the requirements. So does the University of Michigan.[6] Ohio State and Rutgers accept chemical engineering backgrounds, but not mechanical.[6]

It is asserted that sanitary engineering has now become the broadest of all fields of engineering. If this is true, as it is believed to be, it appears that

5. "Graduate Study in Community Air Pollution Control," Ludwig, H. F. and Butrico, F. A., ATMOSPHERIC POLLUTION, Proceedings of the Ninth Municipal and Sanitary Engineering Conference, Bulletin No. 83, Florida Engineering & Industrial Experiment Station, Gainesville, Florida, August, 1956.
6. Final Report of 1953-54 Subcommittee on Graduate Academic Education, Committee on Training, Engineering Section, American Public Health Association, November, 1955.

more institutions in the southeast should follow the lead of Harvard and Michigan and recognize that for some phases of sanitary engineering the subjects taken in undergraduate courses in chemical and mechanical engineering are equally as good as civil engineering subjects, and that all southeastern institutions should allow full credit for work taken in such courses. This, of course, is a problem to be solved by the institutions themselves, but it is a real problem of which the solution may not be readily apparent to the faculty of a civil engineering department administering a sanitary engineering program.

It could be time consuming if not difficult to sell to a graduate school. One reason is because it requires deviations from established policies and regulations which are perfectly reasonable in most cases but which do not allow for the special needs of sanitary engineering education.

SUMMARY AND CONCLUSIONS

From the foregoing, it might appear that the sanitary engineering needs in the southeast are greater than in other sections of the country. While this may be true in certain respects, the overall picture in the southeast is considered quite good. A real achievement was accomplished at the University of Florida in 1955 with the inception of a Ph.D. program in sanitary engineering. The program allows for specialization in one of any of the following fields:

a) Water supply and wastes engineering,
b) Sanitary engineering design, or
c) General sanitary engineering, including environmental sanitation, air pollution, and radiological health.

Development of the graduate studies in air pollution and radiological health are considered especially significant and the southeast is one of the few sections of the country where specialized work is offered in these fields. Excellent research facilities are also provided in a climate which permits practical field work the year around, and a well qualified staff is available for directing the work.

Among the other southeastern states having good sanitary engineering education programs are North Carolina and Georgia. It is also believed, however, that undergraduate scholarships, more graduate scholarships, more and better research grants, summer employment, and recognition of baccalaureate degrees in chemical and mechanical engineering as meeting the entrance requirements for graduate work in sanitary engineering, are all needed to help in the sanitary engineering education programs. In the recommendation for full recognition of chemical and mechanical engineering undergraduate work, it is understood, of course, that graduate study should be limited generally to students who have made a "B" average or better in their junior and senior years.

TABLE II. BACHELOR OF SCIENCE DEGREES IN ENGINEERING
University of Florida, 1950-55

	Per cent of Total Number of Degrees					
	1950	1951	1952	1953	1954	1955
Aeronautical	5.2	6.5	5.4	3.6	5.7+	7.4
Agricultural	0	0	1.2	0	0	1.6
Chemical	9.1	6.9	9.6	12.9	7.9	8.5
Civil	27.5	19.8	27.1	21.6	21.6	17.0
Electrical	26.1	26.7	22.3	28.8	28.1	30.4
Industrial	13.3	19.8	13.9	17.3	18.0	11.7
Mechanical	18.8	20.3	20.5	15.8	18.7	23.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

TABLE III. UNDERGRAUDATE MAJORS IN SANITARY ENGINEERING
University of Florida, 1950-55

	1950	1951	1952	1953	1954	1955
Total receiving degrees	10	11	7	6	3	5
Per cent of Civil Engineers	12.7	23.9	15.2	20.0	10.0	15.6
Per cent of all engineers	3.5	4.7	4.2	4.3	2.2	2.6

Paper 1221 SA 2

Journal of the
SANITARY ENGINEERING DIVISION
Proceedings of the American Society of Civil Engineers

SANITARY ENGINEERING EDUCATION: INDUSTRIAL HYGIENE ENGINEERING

Alvin F. Meyer, Jr,* M. ASCE
(Proc. Paper 1221)

FOREWORD

The rapidly changing technology since World War II has created many new problems for the sanitary engineer. It has become readily apparent that the educational training of the sanitary engineer is deficient for solving these problems. Over the past year there has been increased attention as to what the education of sanitary engineers should be. The Publications Committee has collected seven papers dealing with the education of sanitary engineers and has tied them together as a Symposium. As in any symposium where the papers were not prepared for a single presentation there is a certain overlap of ideas. This overlap is most significant as it represents the trend of thinking by various individuals who are most interested in the problem of sanitary engineering education.

This Symposium starts with a discussion of the evolution of sanitary engineering education; where it started, how it has progressed up to today and what it will be tomorrow. This is followed by a discussion of the general educational requirements for sanitary engineers and the needs in the Southeast. The specific requirements for specialties in industrial hygiene, air pollution and industrial wastes are outlined. The Symposium ends with a description of the ICA assistance to sanitary engineering education in Peru. It is hoped that this symposium will stimulate interest in the problem of education for sanitary engineers. The diverse nature of the field has created a considerable problem which will not be solved by any one person or any one committee but only by the combined efforts of all sanitary engineers interested in their field. The papers included in this Symposium are as follows:

1. Paper 1218 Sanitary Engineering Education - Its Evolution by Harvey F. Ludwig, Edmund J. Laubusch and Erman A. Pearson.

Note: Discussion open until September 1, 1957. Paper 1221 is part of the copyrighted Journal of the Sanitary Engineering Division of the American Society of Civil Engineers, Vol. 83, No. SA 2, April, 1957.

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2. Paper 1219 Sanitary Engineering Education - General Requirements by Daniel A. Okun.
3. Paper 1220 Sanitary Engineering Education - Needs in the Southeast by John E. Kiker, Jr.
4. Paper 1221 Sanitary Engineering Education - Industrial Hygiene Engineering by Alvin F. Meyer, Jr.
5. Paper 1222 Sanitary Engineering Education - Air Pollution Engineering by Harvey F. Ludwig and Frank A. Butrico.
6. Paper 1223 Sanitary Engineering Education - Industrial Waste Engineering by Ross E. McKinney.
7. Paper 1224 Sanitary Engineering Education - ICA Assistance in Peru by Marvin L. Granstrom.

SYNOPSIS

As a segment of sanitary engineering, industrial hygiene imposes certain education requirements which must be satisfied before the engineer is qualified to solve industrial health problems. The question of where industrial hygiene education fits into the overall sanitary engineering education and what is required is discussed.

Before undertaking any discussion on educational requirements for a particular engineering specialty, it is appropriate to consider the functional needs of workers in the field as the end products of the educational process. Training or education should be founded on the varied types of work to be engaged in by the individual receiving it and should be of such a thorough nature as to give an understanding of basic fundamentals, broad principles and philosophy so that the receiver can undertake a wide variety of problems within the specialty area with added technical study.

There have been many definitions of sanitary engineering throughout the years. In essence they may be summarized as follows: Sanitary engineering is an engineering specialty combining fundamental principles of engineering and biological sciences with a knowledge of public health for the orientation of environmental stresses so that they are kept within acceptable limits for health and welfare of man.(1,2) Obviously, such a broad definition encompasses a wide variety of functional areas, as air pollution, community planning, industrial hygiene and all the miscellaneous problems of public and industrial health and municipal water and sewage treatment plant design and operation. In the past, engineers concerned with water sanitation were basically civil engineers and those interested in industrial hygiene and related problems came from mechanical and chemical engineering backgrounds. As our technology has advanced, it has become obvious that a chemical engineer may be, with further training, more logically the one to deal with problems of industrial waste and that civil engineers can be equally adaptable to problems of air pollution as can a mechanical engineer. Modern requirements

in sanitary engineering would indicate that a new approach to the problem of overall training is required and that in this training there needs to be definite orientation in the areas thought of as "human engineering" as well as industrial hygiene and occupational health.

Returning for a moment to the broad definition of sanitary engineering outlined above, some guides with regard to basic industrial hygiene training should be developed. Obviously, if this special practice of engineering involves basic engineering, it is apparent that fundamental engineering training is necessary. It is important to remember that there is a marked similarity in all undergraduate engineering courses, regardless of the fact that there is within these courses considerable specialization. As shown in Figure 1, all engineering undergraduate courses consist in general of five areas—the basic sciences, the applied sciences, the applied engineering subjects, administrative and management type courses and, finally, the humanities. Regardless of the course being pursued, all undergraduate engineers have (or should have) a basic foundation of mathematics, physics and chemistry. A knowledge of these sciences, of course, is fundamental to the understanding of problems of noise, toxic chemical exposure and exposure to other abnormalities within the environment. To this basic engineering knowledge for those entering the practice of the specialties of sanitary engineering, there must be added additional capability with regard to biological sciences. While there are some technical differences with regard to wording, there is rather close agreement on this in the recommendations of the Committee on Professional Education of the APHA's "Proposed Report on Educational Qualification of Sanitary Engineers" and the "Proposed Report on Educational Qualification of Industrial Hygiene Personnel."(3,4) It should be remembered, as shown in Figure 1, that this added knowledge must consist of basic biological sciences such as bacteriology, physiology, biochemistry and biophysics; the applied biological sciences such as toxicology, epidemiology, biostatistics and integrated biological sciences, human engineering and industrial practices, public health practices, etc. An individual receiving such a course of instruction should certainly be able to properly adapt to the special needs of a particular job with minimal additional training. It is inevitable that personal interests will develop within the many functional areas of sanitary engineering; nonetheless, proper basic training will give a background which will allow development of such specialties and at the same time equip the individual engineer with a capability to deal with basic problems in the total area. Some jobs require more industrial hygiene and a minimum of general environmental sanitation. Others have a major requirement for general environmental sanitation concern and only a moderate or minimal amount of concern for the effects of occupation on health. (See Figure 2.)

The fact remains that there are some of both of these functional areas in virtually every phase of sanitary engineering today. The consulting engineer designing a water treatment plant must have an appreciation of the fundamentals of human engineering so as to insure that the operation and maintenance of the plant do not impose on the operating force undue or unnecessary physical or psychological burdens, as well as taking into account the problems of potential toxic exposures. Similarly, the specialist in industrial hygiene must certainly have an awareness of the necessities of plant environmental sanitation in addition to the control of adverse environmental factors within the plant.

In the USAF some years back there was established a combined career

field, "sanitary and industrial hygiene engineering." This career field in no way implies that each and every engineer in the medical service is to be competent in all aspects of sanitary and industrial hygiene engineering. It does recognize the fact that there is an overlapping of interest and activities between the problems of basic environmental sanitation and highly specialized problems of the occupational environment. The shortage of engineers existing and continuing to the present made it necessary to cross train personnel and to attempt to fit individual skills and capabilities to job requirements. To a large measure, the modern Air Force is little different from the aviation industry; and the situation described above with regard to personnel is quite typical of that which faces both health departments and industrial establishments. Experience of the Air Force indicates that all engineers concerned with environmental sanitation need to know something about problems of industrial hygiene; and, conversely, those concerned principally with problems of industrial health must have a broad understanding of public health principles.(5) As a matter of fact, this is no new concept. One merely has to refer to classic references to note instruction material available, namely, the chapter on industrial hygiene in Ehler's "Municipal and Rural Sanitation," and the section on sanitary conditions in Volume I, "Industrial Hygiene and Toxicology," by Patty.(6,7)

Obviously, there is a need for specialization within sanitary engineering. This has been recognized by the American Sanitary Engineering Intersociety Board in its certification program whereby certificates for specialists in sanitary engineering will be granted in a variety of specialized fields within sanitary engineering including, in addition to general sanitary engineering, industrial hygiene and air pollution and radiological health.

A suggested program of improved approach to education, not only of sanitary engineers but all engineers, in this problem is as follows:

First, there is a positive need for inclusion in undergraduate curricula for all engineering students of at least 4 to 6 contact hours (preferably in the junior or senior year) on fundamentals of engineering biotechnology, occupational health and safety. The canon of ethics for engineers and engineering registration laws all place on the engineer an obligation for consideration of health and safety aspects of the work he develops and directs.(8) At the moment very few engineering schools teach anything at all relating to health and safety promotion or protection in undergraduate curricula. The engineer is supposed to direct the forces of nature for the benefit of mankind. At the same time he has a further obligation to do this in as economical manner as possible. Without proper orientation in the aspects of environmental exposure in worker productivity, manpower costs, etc., it does not seem possible, nor has experience shown it to be the case, that these obligations will be fully met without such orientation and application.

The APHA Committee on the Industrial Environment has prepared a syllabus on "Principles of Occupational Health and Safety for Engineering and Medical Students." It is designed specifically for use in engineering colleges and in medical schools to give a 4 to 6 contact hour presentation. This could well be done in engineering schools as part of Founder Society Student Chapter meetings or through the medium of inviting guest speakers from industry or health departments to speak at special class meetings. It is anticipated that this syllabus will be submitted to the APHA for publication as a report and will be available early next fall or winter.

Secondly, with regard to more advance knowledge of industrial hygiene

required for specialization in sanitary engineering, it is not unreasonable to suggest that in all graduate training programs in sanitary engineering there be included general concepts and principles in the occupational health field. It well may be that the one year available at present for master of science degrees is insufficient and that the entire time should be spent at highly specialized work in particular problem areas, such as industrial waste disposal. It also well may be that as sanitary engineering evolves further there will be an added requirement for even more years for the advanced training phase. Whether or not the public health and industrial hygiene training should precede or follow the specialist training is a matter of considerable debate. It is necessary, however, to recognize the fact that without knowledge of industrial hygiene subjects as well as the tradiational biological health problems, the engineer is not completely equipped to cope with the problems of the modern environment. More specifically, the graduate curricula for sanitary engineers should include the following occupational health items:

a) Fundamentals of statistics and biometrics—essential to proper analysis of any engineering or health problems if conclusions are to be based on valid opinions and not on chance.

b) Principles of engineering design in control of occupational disease—to include some fundamental information on man-machine relationships as well.

c) Basic principles of physiology and toxicology—to include information on man's anatomic capabilities and limitations, how chemicals enter the body, what their fate is within it, the effects of their presence therein, how excreted and general information on controls of chemical hazards.

d) Mode of action and control of physical agents of disease—to include basic information on noise, abnormalities of temperature, humidity and motion, fundamentals of health physics.

e) Principles of ventilation, air conditioning and air pollution control.

f) Medical aspects of occupational health and safety—to include procedures for physical examinations, relationship of medical procedures to environmental controls, etc.

g) Occupational health surveys—guidance on techniques of making studies of occupational environment with suggestions as to how they may be applied for community studies.

Those already practicing in the many specialties in sanitary engineering always have been active in continually increasing their knowledge both with regard to their special interests and newer problems. This requirement also will exist for those who receive the type of educational program suggested above, for the technique of today and tomorrow may not necessarily be applicable the day after tomorrow. Basic principles and philosophy of operation will still remain, however, as the means of developing the alterations to the environment necessary to promote health and well being.

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SUGGESTED EDUCATIONAL PATTERN

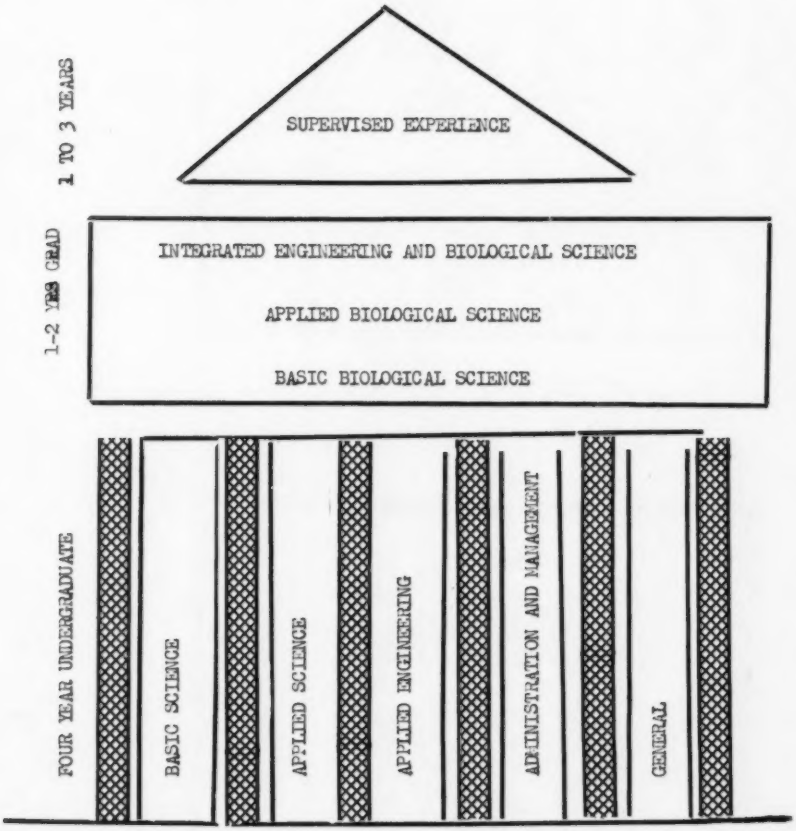
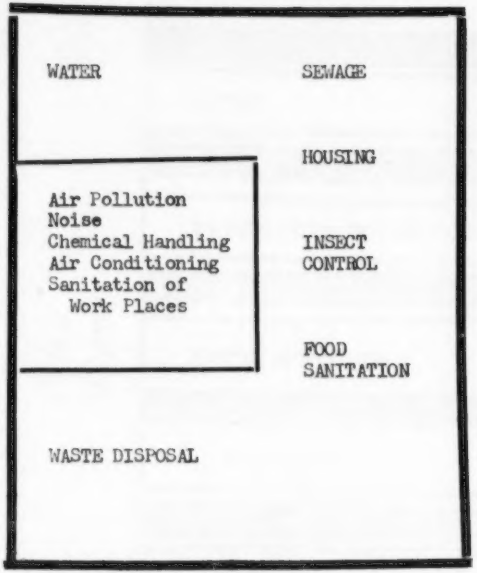


Figure 1



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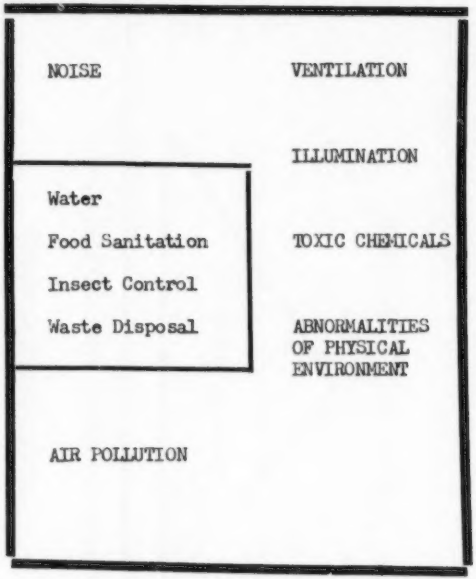

B

JOB REQUIREMENTS

Figure 2

Journal of the
SANITARY ENGINEERING DIVISION
Proceedings of the American Society of Civil Engineers

SANITARY ENGINEERING EDUCATION: AIR POLLUTION ENGINEERING*

Harvey F. Ludwig,[a] M. ASCE, and Frank A. Butrico,[b] A.M. ASCE
(Proc. Paper 1222)

FOREWORD

The rapidly changing technology since World War II has created many new problems for the sanitary engineer. It has become readily apparent that the educational training of the sanitary engineer is deficient for solving these problems. Over the past year there has been increased attention as to what the education of sanitary engineers should be. The Publications Committee has collected seven papers dealing with the education of sanitary engineers and has tied them together as a Symposium. As in any symposium where the papers were not prepared for a single presentation there is a certain overlap of ideas. This overlap is most significant as it represents the trend of thinking by various individuals who are most interested in the problem of sanitary engineering education.

This Symposium starts with a discussion of the evolution of sanitary engineering education; where it started, how it has progressed up to today and what it will be tomorrow. This is followed by a discussion of the general educational requirements for sanitary engineers and the needs in the Southeast. The specific requirements for specialties in industrial hygiene, air pollution and industrial wastes are outlined. The Symposium ends with a description of the ICA assistance to sanitary engineering education in Peru. It is hoped that this symposium will stimulate interest in the problem of education for sanitary engineers. The diverse nature of the field has created a considerable problem which will not be solved by any one person or any one committee but only by the combined efforts of all sanitary engineers interested in their field. The papers included in this Symposium are as follows:

Note: Discussion open until September 1, 1957. Paper 1222 is part of the copyrighted Journal of the Sanitary Engineering Division of the American Society of Civil Engineers, Vol. 83, No. SA 2, April, 1957.

* Presented at Ninth Municipal and Sanitary Engineering Conference, University of Florida, Gainesville, Florida, April 17-18, 1956.

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b. Chief, Office of Eng. Resources, Public Health Service, U. S. Dept. of Health, Education, and Welfare, Washington, D. C.

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6. Paper 1223 Sanitary Engineering Education - Industrial Waste Engineering by Ross E. McKinney.
7. Paper 1224 Sanitary Engineering Education - ICA Assistance in Peru by Marvin L. Granstrom.

SYNOPSIS

The increased importance of air pollution in modern technology is creating problems which must be solved. At the present time the sanitary engineering education falls short of preparing the engineers for solving air pollution problems. A new curriculum for specialists in air pollution is outlined.

All of us are aware of the increasing importance of air pollution as an inescapable facet of modern metropolitan living. With every index of the future pointing to a continually accelerating technology, and attendant further expansion of our metropolitan complexes, it is increasingly apparent that air pollution will be a key factor limiting the ultimate growth of these areas. Los Angeles, for example, is a city whose future development will depend considerably on the success to which it can bring its smog problem under control.

Obviously this is a situation offering great opportunities to the sanitary engineer. Provided he shows real qualities of leadership, the sanitary engineer can play the key role in the development of air pollution control programs. The situation presents, in a sense, an "acid test" of whether the sanitary engineering profession can really do a job in new fields of environmental control which differ radically from our traditional types of operations.

A most important need at this time, if the sanitary engineer is to meet the challenge of air pollution, is to determine what additional technical training should be provided to equip him to do the job, and for the schools of engineering to implement curricula furnishing such training. The problem is very timely for us in the Public Health Service, since a number of our officers have already been assigned to advanced training in preparation for the urgent needs already upon us.

The problem may be approached in three aspects—what should be the technical background of those to be trained, what additional types of training are needed, and to what degree. In attempting to answer these questions, a

preliminary task is to review briefly what the air pollution problem is, as we comprehend it today, in order to establish a sound basis for a training proposal.

Of primary concern to the engineer are the sources of pollution. Basically these are (1) the products of incomplete combustion of fuels used in the home, in industry, or for transportation, or from the burning of refuse, such as smoke, soot, fly ash, cinders; and (2) other products emitted from industrial processes, comprising the whole gamut of dusts, vapors, gases and mists. These various contaminants mix and react under atmospheric conditions to result in the unwanted effects of polluted air.

Industry is usually blamed for most of the problem, but careful evaluation will show there are other important contributors. However, industry does make a good starting point for studying the problem and it behooves the engineer to become familiar with industrial processes in order to understand what is happening to cause this part of the air pollution problem and to determine the chemical and physical properties of the contaminants. The latter are particularly important in predicting the behavior of the contaminants in the atmosphere and their effect on humans and other animals and on plants and damage to property.

Meteorology is another extremely important factor in air pollution control. The weather elements may work to disperse or remove the contaminants below critical levels or to permit their accumulation thus resulting in nuisances and even health hazards. Meteorology is also an important factor in determining methods of control. As in much of our other sanitary engineering control work, the degree of treatment or control is dictated by the ability of the receiving media—in this case the atmosphere—to dilute, disperse, and purify the contaminants.

In order to assess the air pollution problem in a quantitative manner, air sampling is necessary. The problems involved in sampling air and other gaseous mixtures have been recognized and studied in connection with industrial hygiene problems. Extending this basic knowledge to outdoor air pollution sampling presents many new problems in the development of sampling techniques and equipment. Analysis of the sample to obtain qualitative and quantitative information on the nature of the contaminants is also extremely important. Such analyses permit study of the unwanted effects of the contaminants and indicate the corrective action to be taken.

Besides the many technical aspects of this problem, the engineer must also have an appreciation of the economics involved. It would not be sound engineering practice to require a higher degree of treatment than is needed and to recommend control measures which are so expensive and out of line with the magnitude of the operation that industry is forced out of business. Air resources, like water resources, have a legitimate dual role—supplying an essential to life on the one hand but on the other serving to receive and dispose of wastes materials discharged to them through the purification processes naturally occurring in the atmosphere. The economic problem is to maintain a proper balance—a balance which permits maximum utilization of air resources for waste disposal purposes without overtaxing the atmosphere's assimilative capacity, thus maintaining an air environment conducive to human health and well-being and to the preservation of recreational and property values. Of primary importance in the total economic picture is, of course, the need to prevent damage to human health. Although the health effects of air pollution are not yet well understood, particularly the long-range

or chronic effects, if any, as related to respiratory impairments, allergies, cancer, fatigue, mental disturbances, etc., there is little doubt that the health factor is a dominant one in the public mind and is the primary basis of most of the air pollution control legislation coming into being.

Elements of Training Program

From the foregoing we can, in a general way, summarize the type of competencies which the engineer needs to cope with the many problems in the air pollution control field. These include competencies in:

1. Sampling and analytical techniques and equipment used for aerosols, gases, and vapors in the atmosphere.
2. Chemistry.
3. Meteorology.
4. Chemical and mechanical engineering as related to industrial processes and fuels and to air cleaning.
5. Physiological aspects.

Before attempting to answer the three questions mentioned earlier, it should be pointed out the type of training being suggested is not intended to produce highly specialized technical staff such as meteorologists, chemists, economists, etc., all of whom are necessary in a well-rounded air pollution control staff. Instead, we are considering engineering personnel who have already received some substantial training in the basic sciences and whose competencies, reinforced with additional training, can effectively find wide application in the solution of the rapidly evolving and numerous problems of community air pollution.

Desirable Technical Background

Now to consider our first question—what should be the technical background of those to be trained?

From our review of the subject, it appears the sanitary, "straight civil," chemical, or mechanical engineer has the best basic training to pursue graduate study in air pollution control. Each, by his previous training, is better qualified for certain aspects of the air pollution problem. For example, the sanitary engineer is most familiar with pollution abatement problems and is trained to think in terms of hazardous substances which affect human health and well-being, and the chemical engineer is more familiar with the process industries. However, each of the disciplines has certain basic deficiencies which need to be rectified in a graduate training program.

Proposed Curricula

The following is proposed as a one-year graduate program for the engineer who has his basic engineering degree in one of the disciplines mentioned above—the tentatively suggested course would include:

1. A one-semester survey course on air pollution fundamentals. This would cover the nature of the problem, its history and interrelationship

with other fields, legal aspects, and application of fundamentals to air pollution problems.

2. A laboratory course on sampling and analysis of pollutants of interest including gases, mists, vapors, dusts, and radioactive materials. The amount of material which needs to be covered would probably require a full year.

3. A basically chemical-mechanical engineering course of one-year duration on industrial processes, combustion of the air pollution engineer with industrial production and control processes. Such a course, specially designed for air pollution control purposes, would combine and consolidate subjects now offered over a two-year period in most chemical or mechanical engineering curricula.

4. A one-year course in basic chemistry especially pertinent to air pollution control engineering. This would include consideration of the organic, physical, colloidal, radiochemical, and other aspects, and again would consolidate material now offered in present chemistry curricula over a two-year period.

5. A one-semester course covering the basic meteorology fundamentals for one semester, followed by a second semester which would not be either standard meteorology or micrometeorology but a combination encompassing the area of particular interest to the sanitary engineer. This course would be heavily slanted to a study of diffusion problems in the lower atmosphere.

6. A one-semester course in applied physiology. This should probably be divided half on basic fundamentals and half on the specific effects of air pollutants on health.

7. A one-semester course on air cleaning technology and other engineering methods for air pollution control.

8. A one-semester course in applied statistics. This can advantageously be completed by many students prior to commencement of the one-year program, inasmuch as such courses are available at most colleges and are often given at night. In any event the student should have already completed a preliminary course in elementary statistics.

The curriculum as outlined should normally be expected to qualify the individual for the Master's degree. Although this curriculum has little room for sanitary engineering courses as now established in most schools of sanitary engineering, it is not believed these courses as established are sufficiently adapted to the air pollution control field of work to justify their selection in lieu of the courses as recommended. If the individual has had no prior formal training in sanitary engineering, and wishes to gain competence also in the conventional aspects of sanitary engineering, this additional objective should preferably be achieved by lengthening his program beyond the two-semester base.

This brings us to our last point—what degree of training should be required? The answer to this question will depend of course on the individual's basic training and experience and the intended ultimate use of the knowledge gained. The one-year program as outlined is, on the basis of Public Health Service experience to date, considered a good beginning, especially if the

individual has already had some experience in the air pollution control field. For individuals showing real promise a two-year program should prove advantageous in the long run, with the second year devoted to really specific attention to one or more selected aspects of air pollution control.

The Public Health Service is currently supporting this type of program for a number of its engineer officers, with a gap of one or more years between the first and second year of study during which the individual is assigned to work in the Service's air pollution control program. The interval permits the individual to gain practical experience, thus giving him a firm foundation enabling him to benefit from the second year to the fullest. It makes it possible for the student to prepare for his further training so that, in many instances, he will be able to complete requirements for the doctorate degree without being away from the job more than two years.

We should note here that, regardless of the training programs which may be developed now, actual experience in the air pollution control field will no doubt dictate continuing changes. Training programs should not be so highly specialized that changes in air technology will render them obsolete in a relatively short time.

Immediate Problems in Administration

The experience of the Public Health Service officers, who have already undertaken graduate study in air pollution control, has pointed up some serious administrative problems. The student now so enrolled finds himself in the situation of the cart before the horse. If he selects a program such as that outlined above he probably will not qualify for an advanced degree, because existing approved study programs in most engineering schools will not permit this degree of variation. The established programs—organized primarily around concepts quite different from air pollution control—are more or less fixed for the bulk of the work involved, hence they leave little latitude for the student to include the courses described above, even when offered, unless he extends the period of his program to include both. Although both the authors received their training in schools of sanitary engineering organized in the traditional manner, with emphasis on the water phase of environment, we do not believe it realistic for schools of sanitary engineering to expect students whose primary interest is in the air phase of environment to devote a major effort to the details of water supply, waste treatment, stream pollution control, etc. Schools of sanitary engineering must design curricula fitting the real need, else such curricula will be established in other schools, such as in industrial hygiene (which thus far have been primarily devoted to the "indoor" aspects of air pollution—a field somewhat different from community air pollution) or in chemical or mechanical engineering.

A practical approach would be the organization in the university of administrative mechanics which permit the student to pursue a curriculum such as outlined above, made up of courses given and specially designed for the purpose by the various departments involved (chemical engineering, chemistry, meteorology, industrial hygiene, etc.), with the school of sanitary engineering serving as the administrative hub as well as offering those courses possible within its resources. This is the same device already used by several universities for establishing departments in regional and city planning. Such curricula might lead to degrees in sanitary engineering—in the air pollution control option. The situation presents an interesting challenge to the established schools of sanitary engineering, and the developing picture will shed much light on what the term "sanitary engineering" really means.

Paper 1223 SA 2

Journal of the
SANITARY ENGINEERING DIVISION
Proceedings of the American Society of Civil Engineers

SANITARY ENGINEERING EDUCATION: INDUSTRIAL WASTE ENGINEERING

Ross E. McKinney,[1] J.M. ASCE
(Proc. Paper 1223)

FOREWORD

The rapidly changing technology since World War II has created many new problems for the sanitary engineer. It has become readily apparent that the educational training of the sanitary engineer is deficient for solving these problems. Over the past year there has been increased attention as to what the education of sanitary engineers should be. The Publications Committee has collected seven papers dealing with the education of sanitary engineers and has tied them together as a Symposium. As in any symposium where the papers were not prepared for a single presentation there is a certain overlap of ideas. This overlap is most significant as it represents the trend of thinking by various individuals who are most interested in the problem of sanitary engineering education.

This Symposium starts with a discussion of the evolution of sanitary engineering education; where it started, how it has progressed up to today and what it will be tomorrow. This is followed by a discussion of the general educational requirements for sanitary engineers and the needs in the Southeast. The specific requirements for specialties in industrial hygiene, air pollution and industrial wastes are outlined. The Symposium ends with a description of the ICA assistance to sanitary engineering education in Peru. It is hoped that this symposium will stimulate interest in the problem of education for sanitary engineers. The diverse nature of the field has created a considerable problem which will not be solved by any one person or any one committee but only by the combined efforts of all sanitary engineers interested in their field. The papers included in this Symposium are as follows:

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Note: Discussion open until September 1, 1957. Paper 1223 is part of the copyrighted Journal of the Sanitary Engineering Division of the American Society of Civil Engineers, Vol. 83, No. SA 2, April, 1957.

1. Asst. Prof. of San. Eng., Mass. Inst. of Technology, Cambridge, Mass.

2. Paper 1219 Sanitary Engineering Education - General Requirements by Daniel A. Okun.
3. Paper 1220 Sanitary Engineering Education - Needs in the Southeast by John E. Kiker, Jr.
4. Paper 1221 Sanitary Engineering Education - Industrial Hygiene Engineering by Alvin F. Meyer, Jr.
5. Paper 1222 Sanitary Engineering Education - Air Pollution Engineering by Harvey F. Ludwig and Frank A. Butrico.
6. Paper 1223 Sanitary Engineering Education - Industrial Waste Engineering by Ross E. McKinney
7. Paper 1224 Sanitary Engineering Education - ICA Assistance in Peru by Marvin L. Granstrom.

SYNOPSIS

The current sanitary engineering education with its undergraduate civil engineering and graduate sanitary engineering fails to train engineers to properly solve industrial waste problems. The best background lies in chemical engineering or in the new biochemical engineering.

Traditionally, sanitary engineering education has been based on civil engineering since most of the sanitary engineering projects have dealt with municipal works. For the first half of the 20th Century the nature of sanitary engineering projects were of such a character as to require a strong civil engineering background. World War II and the tremendous industrial expansion following the war have created sanitary engineering problems which cannot be satisfactorily solved by the traditional civil engineer. The major problems are industrial waste disposal, radioactive waste disposal and air pollution from both municipalities and industry. It is the purpose of this paper to discuss the educational background of the sanitary engineer engaged in industrial waste disposal.

Nature of Problem

Naturally, the question arises as to whether or not the current sanitary engineering education is sufficient for solving industrial waste problems. The present sanitary engineer with his civil engineering background has dealt with the disposal of liquid organic wastes from municipalities. It would seem that the disposal of industrial wastes would be only a slight modification of municipal waste disposal. While this has worked to some extent, it has not proved satisfactory to industry. The demands of industry are not the same as municipalities and the engineer has found himself largely unable to adapt to industrial waste problems.

The solution of industrial waste problems requires a thorough knowledge of process chemistry and process engineering. The only permanent answer for any industrial waste problem is elimination of the wastes. Complete elimination of industrial wastes is impossible; but reduction of some wastes

can often be brought about by better housekeeping or slight process changes. Once the wastes have been reduced to a minimum, some type of waste treatment must be provided.

The receiving body of water is the first waste treatment system to consider. It must be ascertained as to how much wastes can be discharged directly to the river. To do this a complete evaluation of the water uses and the effect of the wastes on the organisms in the water must be made. If the receiving water cannot absorb all of the pollutional matter in the wastes, a waste treatment plant must be designed and constructed. From the evaluation of the receiving water and the wastes it is possible to determine what effluent quality is required.

The waste treatment plant must be designed to take advantage of physical, chemical or biological processes to bring about production of the desired effluent quality. The selection of the proper waste treatment process requires a thorough knowledge of chemistry and microbiology. Once the process has been selected, it must be translated into a completed structure. The system must be hydraulically sound as well as structurally complete. Industry makes considerable use of short term construction with wood, plastic and steel rather than long term construction with concrete.

It can be seen that the nature of industrial waste problems require a knowledge of chemistry, microbiology, aquatic biology, chemical engineering, mechanical engineering, electrical engineering and civil engineering. Like the wastes themselves, the industrial waste engineer must be a mixture of many talents.

Civil Engineering Background

Civil engineering is the most common background for sanitary engineering. The foundation of structures and hydraulics combined with some electrical engineering and some mechanical engineering have given the civil engineer the knowledge required to design and to construct the basic waste treatment structures used in domestic sewage disposal systems. Specialization in sanitary engineering gives the engineer knowledge of the basic waste treatment processes used in domestic sewage disposal as well as the few chemical tests and bacteriological tests required to determine the efficiency of the process units.

At the present time the civil engineering education is pretty much standardized at a four year undergraduate curriculum. In most engineering schools one or two sanitary engineering courses are taught at the undergraduate level. Unfortunately, the tendency at some of the larger engineering schools, such as M.I.T., is to put the undergraduate sanitary engineering courses as electives rather than as required courses. As a result, most of the civil engineering students avoid the sanitary engineering courses unless they have a reputation of being "soft" courses.

The weaknesses of the civil engineering education are the lack of microbiology, aquatic biology, chemistry and chemical engineering. These weaknesses must be removed before the engineer can hope to solve industrial waste problems.

Chemical Engineering Background

With increased emphasis on industrial wastes the chemical engineer is

becoming aware of the potential for his services in this area. The chemical engineer has a strong chemical base on which is added hydraulic, electrical and mechanical engineering as well as materials of construction. His knowledge of unit processes and their functions in plant operation makes the chemical engineer valuable in solving in-plant problems such as waste reduction and process changes. The weaknesses of the chemical engineering education are the lack of microbiology, aquatic biology and hydrology.

Civil vs Chemical

It is readily apparent that an undergraduate background in chemical engineering is far better training for industrial waste engineering than civil engineering. But both undergraduate curricula fall short of providing the proper background. The deficiencies of civil engineering and of chemical engineering are of such a magnitude that additional education is required for both.

Sanitary Engineering Education

Sanitary engineering is basically a graduate curriculum. The function of the sanitary curriculum is to fill in the missing blanks. Originally, sanitary engineering education was directed towards the deficiencies of the civil engineer. This is still the case in most of the universities and colleges. Graduate training lasts approximately one year and gives bacteriology, analytical chemistry and process design and operation for water and sewage. The courses are, for the main, at the sophmore and junior level even though given graduate level status.

In recent years the emphasis on industrial wastes has caused some of the graduate sanitary engineering schools to change their sights. No longer is the graduate sanitary engineer being trained just for municipal engineering. The larger schools in sanitary engineering, such as M.I.T., have shifted emphasis from water and sewage alone to include industrial waste disposal as a major portion of the curriculum. Chemical engineers are being admitted on an equal footing with civil engineers.

The graduate sanitary engineering training gives the civil engineer microbiology, aquatic biology and analytical chemistry; but still fails to give him the necessary organic, physical and process chemistry required. On the other hand the chemical engineer receives the microbiology, the aquatic biology and the hydrology necessary to form a complete foundation for solving industrial waste problems.

Biochemical Engineering

At the present time the chemical engineers are not overly interested in industrial waste disposal as a group, but this is changing. The need for understanding biochemical processes is being recognized by some of the chemical engineering schools where courses in biochemical engineering are being given by the biology and the chemical engineering departments. Once the chemical engineer combines biological phenomena with chemical engineering, the undergraduate biochemical engineer will stand head and shoulders above the undergraduate civil engineer in the race towards the industrial waste treatment market and will have an advantage over the sanitary engineer with a civil engineering background.

CONCLUSIONS

It appears from the nature of industrial waste problems that undergraduate chemical engineering combined with graduate sanitary engineering or the new biochemical engineering is the best educational background for the industrial waste engineer. While undergraduate civil engineering combined with graduate sanitary engineering form the best educational background for municipal sanitation problems, they do not properly prepare the sanitary engineer for industrial wastes.

Until the chemical engineers become fully aware of the industrial waste problems and aim their graduates at this potential market, the sanitary engineers will have the rule of the roost in spite of their lack of training. As chemical engineers become aware of the industrial waste field, the sanitary engineering departments will either split into two sections or will move either towards civil engineering and municipal engineering or towards chemical engineering. It will be impossible for the sanitary engineering schools to steer a middle path as there will be no middle path. In practical engineering you either solve the problem or you do not; there are no half solutions.

Paper 1224 SA 2

Journal of the
SANITARY ENGINEERING DIVISION
Proceedings of the American Society of Civil Engineers

SANITARY ENGINEERING EDUCATION: ICA ASSISTANCE IN PERU

Marvin L. Granstrom,* A.M. ASCE
(Proc. Paper 1224)

FOREWORD

The rapidly changing technology since World War II has created many new problems for the sanitary engineer. It has become readily apparent that the educational training of the sanitary engineer is deficient for solving these problems. Over the past year there has been increased attention as to what the education of sanitary engineers should be. The Publications Committee has collected seven papers dealing with the education of sanitary engineers and has tied them together as a Symposium. As in any symposium where the papers were not prepared for a single presentation there is a certain overlap of ideas. This overlap is most significant as it represents the trend of thinking by various individuals who are most interested in the problem of sanitary engineering education.

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* Associate Prof. of San. Eng., Univ. of North Carolina, Chapel Hill, N. C.

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ABSTRACT

The Department of Sanitary Engineering, School of Public Health, University of North Carolina has, under the sponsorship of the International Cooperation Administration, an agency of the United States Government, a contractual arrangement to provide technical assistance to the Faculty of Sanitary Engineering of the National University of Engineers, Lima, Peru. The experiences of this project is the subject of this report. The undergraduate teaching program of the Faculty of Sanitary Engineering in Lima has been modernized and made more effective by the recruitment and training of full-time personnel, by the expansion of laboratory teaching, by streamlining and coordinating course content, participating in extension work and by general improvement of all activities.

The other major departments of sanitary engineering in South and Central America are: At the University of Mexico, a graduate department which receives part of its support from the Institute of Interamerican Affairs; at the School of Public Health at Santiago, Chile, a graduate department partially supported by the Pan American Sanitary Bureau, a section of the World Health Organization; and at the School of Public Health at San Paulo, Brazil, a graduate department originally supported by the Rockefeller Foundation.

INTRODUCTION

Probably one of the most important factors in the total development of a group of people is the health of those people. In the United States and other countries over a period of less than a century, teams of dedicated public health workers have been instrumental in, among other important contributions, the reduction and in some cases the practical elimination of many of the communicable diseases which plague man. By doing so they have raised the health level of the people sufficiently to allow other developments to ensue. Important members of these teams have been, and are, the sanitary engineers. We engineers have by no means solved all of our problems; however, we now have skills and knowledge which, when properly applied, can have a great influence in the reduction of many of the communicable diseases and in the general improvement of the health and wellbeing of the body politic.

In many parts of the world little has been done in this area and much work confronts us. One of the countries which needs help is Peru.

Each of us who has spent time on the project in Peru has availed himself to the opportunity to visit the several areas of the country; the divergencies in geography and cultures made this mandatory if we were to understand the problems of all of Peru. The three areas are the narrow and arid coastal plain, inhabitable only in the narrow river valleys of which there are about 50; the mountains with their wide valleys and plateaus where most of the people live and the true tropical jungle area in which the water ways are the only means of transportation. The people in each of the sections of the country have cultural patterns which are distinguishing. In addition to geographical separation, there is a social stratification which is not only pronounced but nearly impenetrable. The population of eight or nine million people may be divided into three categories: the rich upper class, which is very small, is primarily of Spanish descent, the middle class is a mixture of Spanish and Indian and the very large and very poor lower class is almost pure Indian. The pattern of living of this latter group is probably poorer now than what it was when the conquistadores swept over Peru in the early part of the sixteenth century. Of course, there is some intermingling but the geographical barriers and the social stratifications result in many diverse groups which are separate and distinct from one another.

The economy of Peru is largely agricultural—the main export items are cotton and sugar. Next in importance, and sure to gain, is the mineral industry, and the last is the manufacturing industry which is not very well developed. Almost all of these activities are controlled by absentee owners. Peru is a poor country and, even though attempts are being made to improve the basic wealth, there has been more apparent activity in a social welfare program which covers but a fraction of the total population.

As you can imagine from the above description, the problems of public health are tremendous and it is only with some knowledge of the country that we were able to plan our program.

Background

As foreigners we lacked appreciation of the procedures necessary to put into operation grandiose schemes and programs; so our efforts were not directed toward such activities. Rather, we tried to evaluate the problems in order of their importance and in order of the practicability of their solution. Our belief is that we should work on the teaching activities to direct those activities toward training students and educating them in such skills and knowledges that they will be equipped to work out the procedures to attain the most practicable methods of sanitation control.

There is in Peru a well established Ministry of Public Health and also a Servicio Cooperativo Interamericano de Salud Publica which complements and serves as a demonstration and training unit for the Ministry. In some areas of work these two organizations are doing well; however, their progress is slow due in part to inadequately trained and oriented personnel.

Since there are few trained sanitary engineers, only about 15 of the approximately 70 graduates of the Department there have had graduate training in the United States, essentially no sanitarians, and a very limited number of other public health personnel in Peru, it is necessary that the sanitary engineering students have a broad training and good comprehension of the health

and sanitary sciences and public health principles as well as the technical or engineering courses in their curriculum. And, since 1942, the beginning of the Faculty of Sanitary Engineering, the program has included courses in bacteriology, parasitology, epidemiology, municipal and rural sanitation, malariology, chemistry and water analysis, as well as courses in water supply, water treatment and sewerage and sewage treatment. Thus there were plenty of course offerings; however in general the program was not strong. The major weaknesses were two-fold: first, all of the instructors were visiting lecturers who earned their living at other jobs, and second, the budget for operation was a fraction of what it should be. This combination of circumstances led to a practically pure lecture approach with little correlation between courses. The twelve part-time lecturers and instructors have all had graduate training so the courses were well flavored by Harvard, North Carolina, Michigan, etc. The laboratory teaching was pitifully inadequate; only two courses had actual laboratory sessions and the supplies and equipment for these were almost nonexistent so they were in fact more like demonstrations than student participation periods. There was no field training or extension work. Schedules were not followed very closely; for example, the Faculty of Sanitary Engineering usually began teaching about two weeks after the start of school, and the laboratories would begin about two weeks after that. In addition there are many national holidays and two one month's examination periods per eight and one half month scheduled period. Also both the students and the professors were very nonchalant about attending classes, with little attempt for make up. The students were graded almost entirely on the results of the final exams. At the present time most of the sanitary engineers are working in the Ministry of Public Health and Ministry of Public Works with some in consulting offices, sales and construction.

The head of the department, Luis Mantilla F., was well aware of the deficiencies of this type of program and was able to interest the International Cooperation Administration (then Foreign Operations Administration) office in Peru into helping the Department. The School of Public Health of the University of North Carolina was contacted and in April 1954 Dr. E. G. McGavran, Dean, went to Peru to investigate what could be done. In September of that year a contract was signed between the University of North Carolina and F.O.A. F.O.A. allotted $185,000 for a three-year contract and our obligations were quite well defined. The distribution of these funds was approximately as follows: 47 1/2% for personnel including an administrator and a replacement professor in Chapel Hill and a translator in Peru, 6 1/2% for travel and expenses of UNC Personnel, 25% for supplies and equipment for Peru, 11% for training of Peruvians and 10% for UNC overhead. Also F.O.A. through the United States Operation Mission to Peru had a contract with the National University of Engineers in which their obligations were well defined. We were to design, equip and supply laboratories; train personnel; assist in teaching procedures; set up extension courses; set up research, etc. The school in Lima was to provide buildings, office space, transportation, etc., but their most important obligation was to provide three full-time instructors; this has increased the working budget of the Department of Sanitary Engineering several fold and we hope that other departments of the University will find that full-time staff is essential to good operation.

The I.C.A. representative in Lima for this project is the United States Operations Mission to Peru of which our direct contact is Dr. Frederick J.

UNIVERSIDAD NACIONAL DE INGENIERIA
FACULTAD DE INGENIERIA SANITARIA
EL EQUIPO PARA EL LABORATORIO
FUE SUMINISTRADO POR EL
INSTITUTO DE ASUNTOS INTER-AMERICANOS
OFICINA DEL GOBIERNO DE LOS EE. UU. DE N. A.
A TRAVES DE LA
UNIVERSIDAD DE CAROLINA DEL NORTE
OCTUBRE 1955

Figure 1

Plaque in the Laboratories of Sanitary Engineering, National University of Engineers, Lima, Peru.

Vintinner, the Director of the Department of Health Education & Housing. Figure 1 is a picture of a plaque displayed at the Departmental offices in Lima, in which is shown the relationship mentioned above.

Methods of Operation

One of the stipulations of the contract was that the University of North Carolina is to supply full-time personnel in Lima for ten months each year. The names of the professors of the School of Public Health who are to serve, their specialities at Chapel Hill and also the major activities in Lima are as follows: Dr. E. G. McGavran, administration and planning; Dr. Daniel A. Okun, Project Director, administration and engineering; Mr. Emil T. Chanlett, industrial health and sanitation; Dr. Marvin L. Granstrom, sanitary chemistry, hydraulics and engineering; Mr. Gilbert L. Kelso, sanitation and field training; Dr. John E. Larsh, Jr., bacteriology and parasitology; Dr. John J. Wright, administration and epidemiology.

Of the several areas of activity, the one which is considered to be of most importance is that of training personnel. This is accomplished by several means. One is three graduate fellowships to the Department of Sanitary Engineering, School of Public Health, Chapel Hill; second is the leadership traveling grants to three of the major professors in the Department in Peru; and the third is the close working relationships of the people from Chapel Hill with the professors in Lima. By this procedure the senior professors become reacquainted with the working operations of various sanitary engineering activities in the United States, and the Fellows receive technical training. Also part of this training program was to select and provide full-time personnel who would gradually take over many of the administrative and teaching activities. The association in Lima between the professional colleagues of the two countries is helpful to all concerned.

Another activity was the design, construction and putting into operation, laboratories of sanitary chemistry, sanitary biology and hydraulics. There was adequate space in the laboratory building but little else. Figure 2 shows the building in which the department in Lima is located. All of the furniture for the chemistry and biology laboratories, shown in Figures 3 and 4, was manufactured locally and is, incidentally, quite beautiful. The local contractor who was in charge of installation of the utilities which include hot and cold water, electricity, gas, air, vacuum and drain had had no prior experience but eventually it was all operating beautifully. In addition to the standard furniture and fixtures; glassware, reagents, equipment, etc., experimental equipment such as columns, filters, etc., have been designed and constructed. These laboratories are used weekly for courses in bacteriology, parasitology, water and sewage analysis and unit processes of water and sewage treatment. The hydraulics laboratory includes facilities for: calibration of venturi, orifice, elbow, flow and household meters; calibration of weirs, jet trajectories and a Parshall flume; determination of head losses in pipes and pipe fittings; analysis of a distribution system and measurement of velocity distribution in pipes and channels. This laboratory is for use by all of the students in the engineering school.

The next major area of activity is that of revision of course content. This has been accomplished to some degree in the courses of water analysis, sanitary chemistry and biology, unit treatment processes, parasitology, epidemiology, water supply and sewage treatment plant design. To do this we actually

Figure 2

Exterior View of the Laboratories of Sanitary Engineering, National University of Engineers, Lima, Peru.

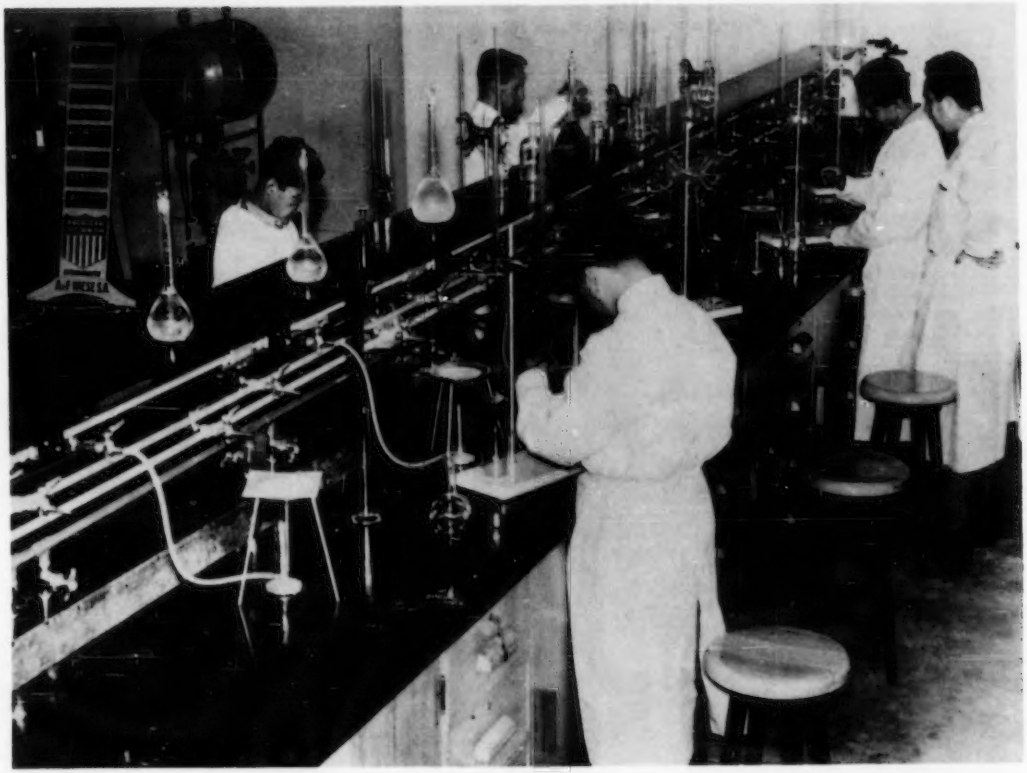

Figure 3

Interior View of the Sanitary Chemistry Laboratory, National University of Engineers, Lima, Peru.

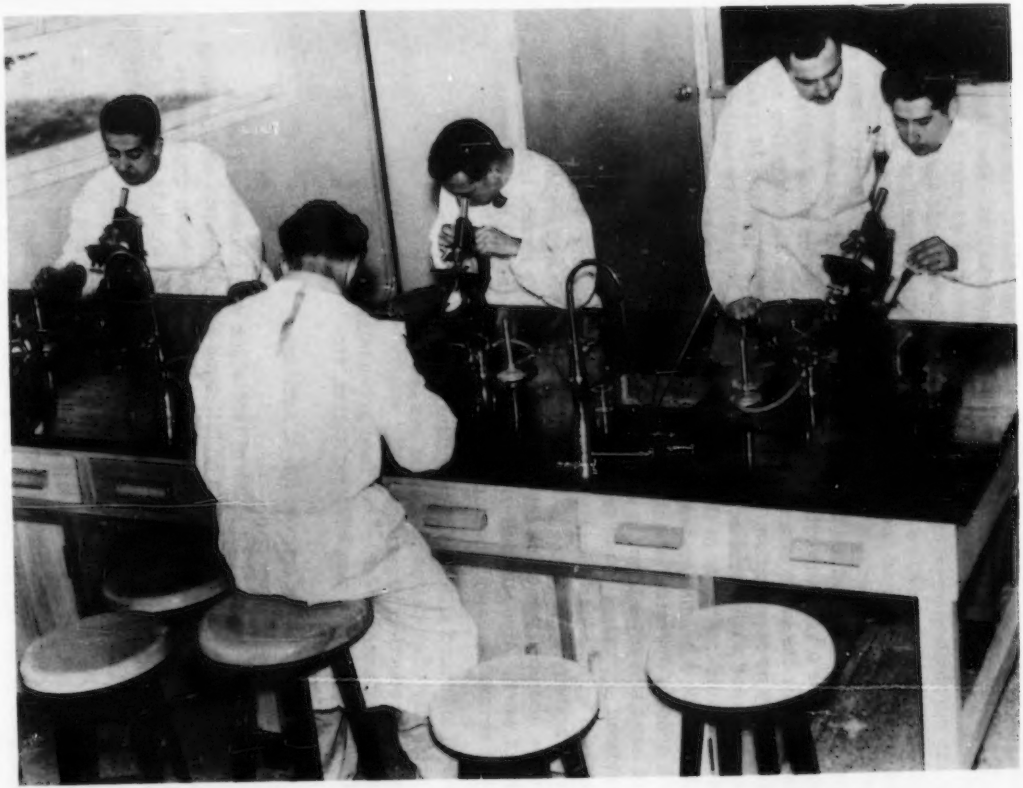

Figure 4

Interior View of the Sanitary Biology Laboratory, National University of Engineers, Lima, Peru.

made out lecture outlines, prepared laboratory instruction sheets, scheduled lectures and laboratories, etc. It was proposed that the present program be shifted from an undergraduate curriculum to a graduate one. This proposal will probably not be accepted in the immediate future. It is the feeling of the Faculty in Peru that the undergraduate plan is more feasible at the present time.

In addition to the activities centered directly in the classroom and laboratories, certain other training procedures have been installed. The first one of these was a four-weeks field training course conducted as part of one of the regular curriculum offerings. This course is divided into three parts: orientation, field visitation, and critique. The objective here was to interest students in public health and environmental sanitation and to acquaint them with the possibilities of service within these areas. The next activity was an extension course conducted for water plant operators. This was assumed and later proven to be a very important area because the water plant superintendents were for the most part civil engineers who had no instruction and have essentially no supervision. For example; in only two of the 14 treatment plants represented at the first school had there ever been either coliform or chlorine determination made of the water. This annual program will be expanded to include a graded system of course instruction having three or four one-week schools operating simultaneously. Another type of extension work is that of night school in Lima in which graduate civil engineers will receive an abbreviated equivalent of the technical sanitary engineering courses. The total program will be four hours per week for forty weeks. This was deemed a desirable activity since many of the design engineers and engineers in administrative and policy-making levels have received no formal training in their line of work. Also, the full-time personnel is starting investigative work. The several areas under consideration are:

1. Use of activated silica as a coagulant
2. Feasibility of oxidation ponds for sewage treatment
3. Aerobic reduction of garbage
4. Methods of sanitary control of food processing plants
5. Utilization of raw sewage for irrigation, etc.

Interpretation of Activities

This project will accomplish much of that which was planned. That is, there is and we hope will continue to be full-time administrative and teaching personnel on the staff in Lima; laboratory teaching is effected; courses are modernized and coordinated; field training and extension work is a part of the Faculty's activities; investigate work is a part of the program; and probably these reforms will set a pattern for the rest of the University.

The major difficulties have been those inherent in a part-time administrative and teaching set-up. That is, delays in administrative action and difficulties in finding convenient times to spend with the individual faculty members to work out plans and programs. As a result, progress was sometimes slow but on the other hand we have always been made to feel as though our efforts were appreciated.

The cooperation between USOM, UNC and UNI has been most cordial and we appreciate the privilege of participating in this program.

SUMMARY

The description of the objectives, methods of procedure and interpretation of activities of the technical assistance program in a sanitary engineering teaching in Lima, Peru, has been described. This is a cooperative activity between the University of North Carolina, Chapel Hill, and the National University of Engineers, Lima, Peru, with the support of the International Cooperation Administration, an agency of the United States Government.

Journal of the
SANITARY ENGINEERING DIVISION
Proceedings of the American Society of Civil Engineers

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(Over)

Note: Paper 1227 is part of the copyrighted Journal of the Sanitary Engineering Division of the American Society of Civil Engineers, Vol. 83, No. SA 2, April, 1957.

*There will be no closing discussion to this paper.

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Discussion of
"TREATMENT OF ALKALINE SULFUR DYE WASTES
WITH FLUE GAS"

Progress Report of the Sanitary Engineering Research Committee,
Industrial Waste Section
(Proc. Paper 1078)

RALPH PORGES,[1] A.M. ASCE.—Sulfur dye wastes have long posed a waste-treatment problem because of their alkalinity, toxicity, and tinctorial properties. Sulfur colors are included in the general group of substantive dyes and consist of sulfur compounds which are generally applied with the addition of sodium sulfide. The waste contains the pigment, sodium sulfide, salt and some minor chemicals from the dye bath and rinses. The authors are to be commended for exploring the use of flue gas to reduce the high alkalinity of the textile waste and to make the waste more amenable to further treatment.

A similar type of treatment process utilizing stack gas for carbonation was developed by Copson and Curtis(1) for Kier liquors. Further study(2) of this process indicated possibilities of an economical method of partial clarification particularly with strong kier liquor wastes.

The use of acid to neutralize sulfur dye waste has not been fully satisfactory because of the evolution of hydrogen sulfide. This difficulty emphasizes the two-fold problem of sulfur dye waste disposal as this waste may be a stream pollutant, an air pollutant, or both. Several mills have endeavored to handle sulfur dye wastes by treating with alum or acid and aeration, or by aeration alone.(5) In either case, the dispersion of the hydrogen sulfide into the atmosphere made the presence of the plant notoriously noticeable even several miles away. Using an iron salt such as copperas ($FeSO_4$) will precipitate the waste without the evolution of hydrogen sulfide and at the same time reduce the pH to desirable limits. The insoluble iron sulfides can be removed before subsequent waste treatment, if needed.

Stripping the waste of hydrogen sulfide by flue gas appears to have considerable merit provided adequate precautions are taken to prevent air pollution. The authors have properly indicated that discharge to a low idle stack under unfavorable meteorological conditions could lead to air pollution problems.

The concentration of the sulfur dye in the plant waste bears on the treatment problem. The authors have indicated that the dyeing operations averaged 24% sulfur colors. Since most other dyes are less polluting than sulfur colors, this amounts to some dilution; analysis of the waste as given in the report appears to bear this out. The effluent, from the pilot plant using the flue gas for neutralization, is further diluted with settled domestic sewage and treated on a trickling filter. The possibility of treating the mixed sewage-dye waste by trickling filters without prior neutralization of the dye

1. Senior San. Engr., Water Supply and Water Pollution Program, Robert A. Taft San. Eng. Center, Cincinnati, Ohio.

waste by flue gas might be explored. Successful treatment of sewage-sulfur dye mixtures by biofiltration and activated slude processes has been reported.(3)(6) Others have reported on the biological treatment of highly alkaline textile mill waste-sewage mixtures.(4)

Another consideration for sulfur dye wast ontrol is reuse of the dye. Experiments conducted several years ago de..onstrated the possibility of precipitating the dye from fairly concentrated waste with alum or copperas, treating the slude with acid to remove the coagulant which can be reused, and recovering the dye. Such a procedure would be useful only to mills where one pigment is used over a period of time and such wastes can be segregated.

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3. Miles, Henry J., and Porges, Ralph. "Textile Waste Studies in North Carolina." American Dyestuff Reporter (December 12, 1938).

4. "Biological Treatment of Highly Alkaline Textile Mill Waste--Sewage Mixture." Progress Report of the Industrial Waste Section of the Sanitary Research Committee of the Sanitary Engineering Division. Proceedings of the ASCE Vol. 81 Paper No. 750 (July 1955).

5. True, Albert O. "Disposal of Wastes from Dyehouses and Textile Operations." Journal of the AWWA. Vol. 11, No. 4. (July 1924).

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Discussion of
"SEDIMENTATION STUDIES"

by D. E. Bloodgood, W. J. Boegly, and C. E. Smith
(Proc. Paper 1083)

N. CLAES H. FISCHERSTRÖM,[1] M. ASCE.—The careful investigation carried out by the authors are a valuable demonstration of the validity of Hazen's theorem.

Hazen's theorem can be applied with accuracy only within certain practical limits. It is an important task to determine such limits. The investigations are carried out within a supposed good, fairly narrow, range and obviously not with the intention to study limiting values, with the exception perhaps of the tests with a single inlet opening. Still an analysis in this respect is of some interest.

In the paper four basins of the same length but with very different cross-sections are studied. The test results will perhaps allow conclusions regarding a possible difference between the sedimentation effect in the basins.

The basins and their characteristic hydraulic values are given in Table 1:

Table 1

Basin, No.	1	2	3	4
Length, L, ft	11.5	11.5	11.5	11.5
Cross-section, WxD, ft	6x2.1	4x2.1	2x2.1	6x1.1
L:W	1:2	1:3	1:6	1:2
Over-flow rate, gpm/sq ft	0.26-1.45	0.36-1.45	0.27-1.45	0.26-1.09
Velocity, mm/s	1-5.4	1.3-5.4	1-5.4	1.9-8
" ft/min	0.2-1	0.3-1	0.2-1	0.4-1.6
Hydr. radius, m	0.372	0.312	0.206	0.247
$\mathbb{R}$, 20°C	360-2100	430-1700	270-1100	460-1900
$\mathbb{F} \times 10^7$	2-80	6-90	9-140	18-314

From the table it can be seen that the hydraulic values (mean velocity, tank Reynolds and Froude number) are extremely good; very few basins in use have such ideal values. All of the tested basins should therefore, from a hydraulic point of view, be well suited to prove the over-flow rate theory in the applied flow range and sediment concentrations. It cannot be expected

1. Civ. Engr., Vattenbyggnadsbyren, Stockholm, Sweden.

therefore that there will be any great difference between the chosen basins or that any limiting values for the application of the Hazen theorem will be obtained. It is of interest to observe that the tank Reynolds number indicates laminar flow at low load but turbulent flow at increased load in the test range. A more detailed study of the sedimentation results might therefore still be tried.

In Fig. 1 the sedimentation effect for basins 1, 3 and 4 are shown. Curve A is the best one possible, based on the sediment analysis. Data from the few tests with concentrated suspensions are excluded, because they consistently show better results than for diluted suspensions. Unfortunately there are not sufficient determinations to allow a mathematical probability analysis.

It is noticeable that all sedimentation curves are inferior to curve A. The differences are fairly great. But as expected there is not much difference between the basins. The curve for the narrow basin 3 (L:W=6) and the curve for the shallow basin 4 (L:W=2) indicates, however, a slightly better effect than the curve for basin 1. If we had no disturbances the effect would be the same. Consequently we have disturbances (if the suspensions are truly identical), possibly from the inlet. Hence the better effect might be due to the better $\mathfrak{R}$ -number in the narrow and shallow basins, which reduces the influences of such disturbances. The water temperature is higher in test series with basin 4, and this can also have some influence.

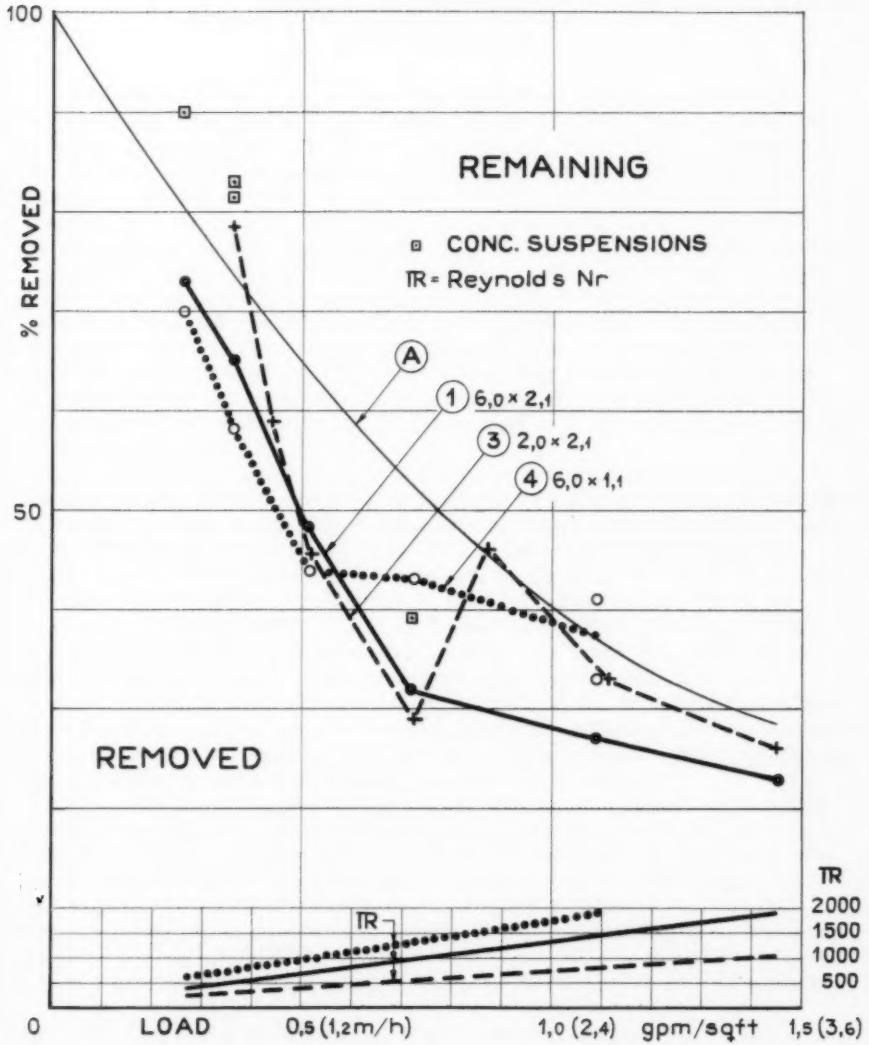
The turbulence as indicated by the tank Reynolds number is shown by the straight lines below on Fig. 1. As is well known, the influence of $\mathfrak{R}$ increases with the decrease in settling properties and decreases with good settling properties, as for grit, etc. There is no evidence from the tests that $\mathfrak{R}$ in the range in Table 1 has any real influence on the settling efficiency with the sediment used.

The very favourable values on $\mathfrak{R}$ at low load in No. 3 series indicating laminar flow may explain the slightly increased effect in relation to No. 1 and No. 4 series. The passing from laminar to turbulent flow might be the cause of the irregularities in the middle of the test series No. 3. The negligible influence of the laminar flow at low load is interesting. The conclusion would be that there is very little to gain when settling sewage by reducing the turbulence to laminar flow.

The relative stability is very good because the tests were carried out only with suspensions with a low amount of Celite, and the Froude numbers were high. The specific weight of the suspension is not given, but is believed to be not very different from that of the effluent. In industrial wastes and in liquids at modern sewage plants we might have 10 or even 100 times more concentrated suspensions and the specific weight of the incoming liquid is then high in comparison to that of the clarified liquid. If we carried out tests with such heavy suspensions and a deeper basin with bad stability and got a poor sedimentation effect, would this be a proof against the HAZEN theorem? The answer is no, because the relative stability of the basin would be poor and the presumptions are hence not fulfilled. The same might be said about the tests by the authors with a bad inlet arrangement. Although it is mostly possible to make a good inlet these tests are nevertheless of a certain interest in respect to the differences in sedimentation effect discussed above.

Once again it must be said that the carrying out of such tests is of great general interest, and the results will be very helpful for the practising engineer. The indicated use of Celite 545 as an appropriate sediment is

FIGURE 1


100
50
0
% REMOVED
REMAINING
CONC. SUSPENSIONS
TR = Reynold s Nr
A
1 6,0 x 2,1
3 2,0 x 2,1
4 6,0 x 1,1
REMOVED
TR
2000
1500
1000
500
LOAD
0,5 (1,2m/h)
1,0 (2,4) gpm/sqft
1,5 (3,6)

valuable, and its use as a possible standard at sedimentation studies would simplify comparison of tests in different places in the world. The writer hopes that the experiments will be extended to study the influence of dense liquids, e.g., such as we soon will meet quite often in sewage purification. We must get a better knowledge about the conditions which a sedimentation basin must fulfil to allow a settling process in close accordance with the HAZEN theorem, when settling extremely dense liquids.

Discussion of
"THE MECHANICS OF REAERATION IN NATURAL STREAMS"

by Donald J. O'Connor and William E. Dobbins
(Proc. Paper 1115)

THOMAS R. CAMP,[1] M. ASCE.—The authors of this paper have made a very valuable contribution to the field of sanitary engineering. Although the paper is directed to the development of a rational theory for the determination of reaeration coefficients for polluted streams, the theory presented is generally applicable to all gas transfer processes. It therefore has wide application in water and sewage treatment. The authors are to be congratulated.

The authors examine the Lewis & Whitman two-film theory of the transfer of a gas to solution in a liquid and show by comparison of the diffusion coefficients that the resistance through the liquid film at the interface is so great as compared to the resistances through the gaseous film at the interface, through the main body of the gas and the main body of the liquid that it controls the entire mechanism. It is also shown that, because of this high resistance through the liquid film at the interface, the concentration of the dissolved gas in the body of the liquid will be substantially uniform even with very slight mixing of the liquid.

Dobbins has previously shown[2] that the liquid film coefficient, K_L, of equation (6) is substantially equal to D_L/L if the liquid film remains unbroken, in which D_L is the coefficient of molecular diffusion of the dissolved gas and L is the thickness of the liquid film. He has also shown[2] previously that, where the film is being renewed continually by shearing forces in the liquid, the liquid film coefficient is substantially equal to the square root of the molecular diffusion coefficient times the rate of renewal of the liquid film, equation (27). In this relation, it will be noted, the liquid film coefficient is substantially independent of the thickness of the liquid film. The writer wishes to point out that only this second expression for the liquid film coefficient has real meaning since any motion whatever in the liquid creates shearing forces which will remove the liquid film. In any real process, therefore, the liquid film is being continuously removed and regenerated.

The evaluation by the authors of the rate of surface renewal, r, in terms of the parameters of modern turbulent flow theory is a significant advance. This development indicates that the rate of renewal of the liquid film at the interface is substantially equal to the velocity gradient of the liquid at the interface for non-isotropic turbulence and is approximately equal to the velocity of the liquid divided by the depth for isotropic turbulence. The basic equation for the reaeration coefficient is the authors' equation (28). In order to use this equation it is necessary to insert a value for the rate of surface

1. Camp, Dresser & McKee, Cons. Engrs., Boston, Mass.
2. Dobbins, W. E., "The Nature of the Oxygen Transfer Coefficient in Aeration Systems," Biological treatment of sewage and industrial wastes by McCabe and Eckenfelder, Reinhold Publishing Corporation, New York, 1956, p. 141.

renewal. Equation (35) is the resulting expression for the reaeration coefficient for non-isotropic turbulence, which also includes a dimensional factor for changing the rate of surface renewal from seconds^{-1} to days^{-1}. A companion expression for the reaeration coefficient for isotropic turbulence is given in equation (37). Equation (37) is in terms of the liquid velocity, presumably the mean velocity in the channel or stream with relation to the bottom. If the velocity, as shown in equation (36), is in fps, a numerical constant similar to the 480 of equation (35) must be introduced in equation (37) if the reaeration coefficient is to be in days^{-1}.

Equation (35) is expressed in terms of the slope of the hydraulic grade line. Equation (37) is expressed in terms of the mean velocity. Since the slope of the hydraulic grade line may be expressed in terms of the mean velocity and a friction factor or coefficient, it is possible to put equations (35) and (37) in the same terms. If this is done, it will be found that the reaeration coefficients are identical with a Chezy C of 14.2.

If, as indicated above, the slope of the river, s, is expressed in terms of the mean velocity, the depth, and the Chezy coefficient, C, the reaeration coefficient in equation (35) takes the form:

$$k_2 = 480 \frac{D_L^{1/2} U^{1/2}}{C^{1/2} H^{3/2}} \qquad (35a)$$

The authors reaeration coefficient in equation (37) is in seconds^{-1} if the velocity is in fps. Hence, if equations (37) and (35) are to have the same dimensions of days^{-1}, the velocity in equation (37) must be expressed in feet per day, or 86,400 times its value in fps. The resulting equation is as follows:

$$k_2 = 127 \frac{D_L^{1/2} U^{1/2}}{H^{3/2}} \qquad (37a)$$

It will be noted that the factor, $480/\sqrt{C}$ in equation (35a) is equal to the factor 127 in equation (37a). When the Chezy C has a value of 14.2, the reaeration coefficient given by equation (35a) is the same as that given by equation (37a).

In verification of the theory, the authors describe in Part I the measurements made of the reaeration coefficient of the water surface of a cylindrical vessel approximately 5-1/2" in diameter with 6-1/4" of water depth containing a lattice-work oscillated vertically in simple harmonic motion at speeds varied from 45 rpm to 120 rpm. The purpose of these tests was to confirm equation (28) which indicates that the reaeration coefficient varies as the square root of the rate of surface renewal. Since from turbulent flow theory the rate of surface renewal should be proportional to speed of oscillation, the reaeration coefficient should be proportional to the square root of the speed of oscillation. The tests verified this relationship as indicated in Fig. 1.

Two sets of experiments were conducted, one with deaerated water and the other with a sodium sulfite solution. The results, as shown in Table II, indicate that the reaeration coefficient for the sulfite solution was much greater than that for the deaerated water, ranging from 22-fold at the lower

speed to about 4.8-fold at the higher speed. This is a very significant difference which the authors pass off with a statement that "Although the sulfite method has been used frequently in the past as a means of measuring oxygen transfer, it has been recently criticized by some investigators."

The sodium sulfite method is based on the assumption that the rate of change from sulfite to sulfate is a direct measure of the rate of reaeration. This undoubtedly is true, but the mechanism of reaeration with the sulfite solution is totally different from that which it is desired to measure. It is desired to measure the liquid film coefficient K_L (i.e., the rate at which oxygen passes through the liquid film to the main body of the liquid) in the absence of appreciable quantities of sulfite or other reducing agents within the liquid film itself. It is reasonable to assume that when a sulfite solution is used the concentration of sulfite within the liquid film must be about the same as in the main body of the liquid. Hence, oxygen from the air will react immediately with the sulfite as it passes through the interface. More sulfite will diffuse through the liquid film to the interface to make up this deficit; and the product of the reaction, sulfate, will diffuse through the liquid film into the main body of the liquid. The rate of reaeration measured with the sulfite solution, therefore, depends not upon the rate of diffusion of dissolved oxygen through the liquid film but upon the rate of diffusion of sulfites outward and sulfates inward through the liquid film. With a concentration of about 8,000 ppm of sulfite in the main body of the liquid as compared to 8 to 14 ppm for dissolved oxygen at saturation, it is obvious that very high concentration gradients may be developed for the diffusion of sulfate inwards to the main body of the liquid.

If the sulfite method has been used frequently in the past as a means of measuring oxygen transfer as stated by the authors, it is curious that the great discrepancy between the rates obtained with sodium sulfite and deaerated water has not previously been discovered. The sulfite method has been widely used for the comparison of efficiencies of different aerating devices. This is probably a valid use of the method, but the sulfite method should certainly not be used to determine the liquid film coefficient K_L for gas transfer.

One of the prime functions of an activated sludge aeration tank is to transfer sufficient oxygen from the air or oxygen gas to the solution to support the biochemical activity in the tank. Similarly, the prime purpose of a carbonation tank is to transfer gaseous carbon dioxide to solution in the liquid. The same fundamental law, the authors' equation (27), applies to both mechanisms.

Equation (27) may be applied in the analysis of aeration in an activated sludge aeration tank by means of a revolving brush at the surface of the mixed liquor. The brush must revolve at a rate to produce a velocity gradient at the surface of ample magnitude to produce the desired value of K_L. At normal temperatures, D is approximately equal to 0.09 cm^2 per hour. If the velocity gradient produced is then 10,000 ft per hr per ft or 167 ft per second per foot, K_L will then be 30 from equation (27). Such a velocity gradient may be produced by the brush at a peripheral speed of about 30 fps if the velocity in the liquid 2 to 3 inches away from the brush is not more than 2 to 3 fps.

In the case of rising gas bubbles, the rate of renewal of the liquid film, r, is proportional to the rising velocity of the bubbles with respect to the surrounding liquid and inversely proportional to the size of the bubbles as follows:

$$r = m \frac{v}{d} \tag{42}$$

in which v is the bubble velocity, d is the size, and m is a proportionality coefficient.

In the viscous flow region of bubble size and velocity, the maximum velocity gradient at the horizontal axis of the bubble is between 2v/d as indicated by Handamard-Rybczynski's law and 3v/d as indicated by Stokes' law. It may be argued, therefore, that the value of m in equation (42) must be considerably less than 2 since it represents an average velocity gradient around the liquid film.

The experimental data of Ippen[3] et al have been analyzed by the writer to determine the actual values of m for rising bubbles as a function of the size of the bubbles. The results of this analysis are shown in Fig. 3.

If the value of r from equation (42) is inserted in the authors' equation (27), the following equation results:

$$K_L = \sqrt{m} \sqrt{D_L \frac{v}{d}} \tag{43}$$

The experiments of Ippen et al included depths of aeration diffusers ranging from 2.1 ft to about 12 ft. The numerals at each experimental point plotted on Fig. 3 represent the depth of the tank in feet. Also shown on Fig. 3 represent the depth of the tank in feet. Also shown on Fig. 3 by means of x's are experimental points in which the water contained a synthetic detergent. The concentration of the detergent in ppm is shown inside the block at each experimental point. Ippen and his co-workers found that the liquid film coefficient was higher for shallow tanks than for deep tanks. When the data are plotted in the terms of the $\sqrt{m}$, as shown in Fig. 3, the evidence is not so conclusive that tank depth has an effect. It will be noted, however, that the presence of detergents has a very marked effect in reducing the value of $\sqrt{m}$ and hence the value of the liquid film coefficient K_L. Fig. 3 also indicates the effect of bubble size on the liquid film coefficient. For example, the value of K_L for 0.6 mm bubbles is only about 40% of the value for 2 mm bubbles. This does not mean that the larger bubbles are more efficient. Quite the contrary. The smaller bubbles are more efficient because they stay in the tank longer and present more interfacial area for gas transfer.

Also shown on Fig. 3 by means of triangles are the results of experiments by Ippen et al with pure oxygen bubbles. The liquid film coefficient K_L for pure oxygen seems to be somewhat less than for air, although the results are not too conclusive. The experiments by Ippen et al were conducted in a lucite tube with an inside diameter of 5.5 inches. From some preliminary experiments with still water in the column, it was found that the rate of oxygen absorption from the atmosphere through the water surface was very small. The experimenters, therefore, concluded that they could safely

3. Ippen, A. T., Campbell, L. G., and Carver, C. E., Jr., "The Determination of Oxygen Absorption in Aeration Processes," Technical Report No. 7, Hydrodynamics Laboratory, M.I.T., May 1952.

Also Ippen, A. T. and Carver, C. E., Jr., "Oxygen Absorption and Turbulence Characteristics in Bubble Aeration," Technical Report No. 14, Hydrodynamics Laboratory, M.I.T., April 1955.

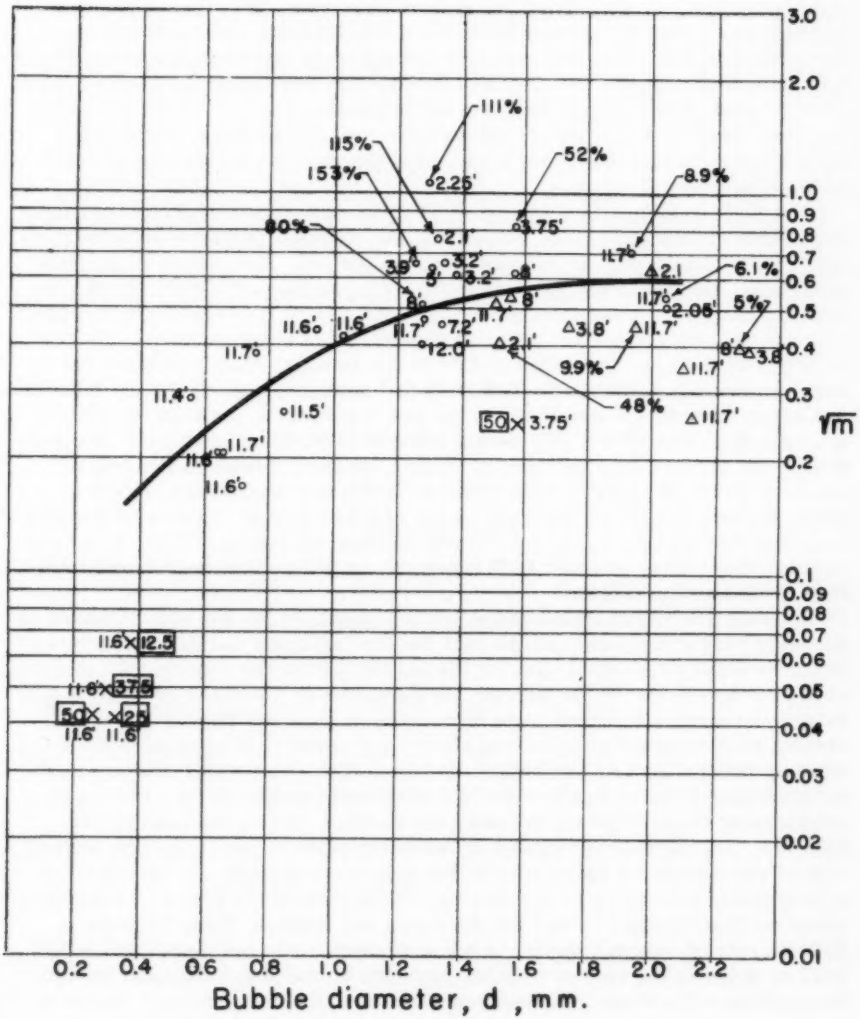

3.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
√m
0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2
Bubble diameter, d , mm.
111%
115%
153%
52%
8.9%
80%
6.1%
5%
48%
9.9%
50 × 3.75'
11.6 × 12.5
11.6 × 37.5
50 × 25
11.6 11.6

Fig. 3

neglect this means of absorption of oxygen in reporting the results of their experiments. In order to investigate this conclusion for turbulent water, the writer has shown on Fig. 3 the ratio of the water surface area to the bubble interfacial area for several of the experimental runs. For the deep columns and high gas flows the ratio of the water surface area to the bubble interfacial area is 5 to 10%, whereas with low gas-flow rates and shallow columns, this ratio is as high as 153%. It will be noted on Fig. 3 that the highest values of $\sqrt{m}$ are for the largest ratios of water surface area. It is not too clear, however, whether there was an appreciable rate of absorption of oxygen at the water surface or whether the spread in the plotted points is due primarily to the experimental error.

Claims have been advanced that most of the absorption of dissolved oxygen in diffused air aeration takes place from the atmosphere at the water surface and that the size of the air bubbles is not important. In order to investigate this claim, the author has estimated the water surface area per unit of volume of aeration tank for diffused air aeration at 1 cu ft per gallon of sewage with a 6-hr aeration period. The aeration tank has been assumed to be 15 ft deep and 23 ft wide. The value of A/V in the authors' equation (6) for the water surface in this example is 0.0022 cm^2 per cubic cm. If the air bubbles are assumed to be 1.8 mm in diameter and to remain in the tank for 10 seconds, the value of A/V for the air bubbles is 0.092 cm^2 per cm^3. In other words, the surface area per unit of volume for the air bubbles is about 42 times as great as for the water surface. If the rate of transfer from the water surface is to be of the same order of magnitude as the rate of transfer from the rising bubbles, the rate of replacement of the liquid film, r, for the water surface must be about 1800 times the rate of replacement of the liquid film for the rising bubbles.

Actually the rate of replacement of the liquid film for the water surface is probably very much less than the rate for the rising air bubbles. The rate of replacement for the liquid film for the air bubbles in the experiments of Ippen et al averages about 50 per second. In the authors' studies of reaeration in natural streams, the highest rate of renewal in the most rapidly flowing stream studied by the authors was about 1 per second. It is reasonable to suppose that the rate of renewal of the liquid film at the water surface of an aeration tank is much greater than 1 per second because of the turbulence produced by the air bubbles breaking the surface. It is quite improbable, however, that the rate of renewal at the water surface can be as high as the rate of renewal of the liquid film on the rising air bubbles. If, for the sake of argument, it is assumed that the rate of renewal of the liquid film for the water surface is equal to that for the rising air bubbles, the conclusion is that the rate of oxygen transfer at the water surface is not more than about 1/42 or 2.4% of the rate of transfer from the air bubbles in an average diffused air aeration tank. The bubbles, therefore, are the principal means by which gas transfer is accomplished, and the smaller the bubbles the more effective the transfer.

Discussion of
"SLUDGE INCINERATION"

by Mark B. Owen
(Proc. Paper 1172)

CORRECTIONS.—On page 1172-12, in the last line of the third paragraph, the word "gauge" should be changed to "range." On page 1172-15, in the first line of the third paragraph, the word "are" should be changed to "is." On page 1172-15, in the second line of the fourth paragraph, the word "cover" should be changed to "over." On page 1172-22, Table IX should have values added to the last column and an additional line added as follows:

TABLE IX

Composition of Materials Burned

Milwaukee Sewage Treatment Plant

Jones Island, June 8-9, 1953

36-hour test

	As received		Moisture	Dry Solids		B.t.u./lb.
	lb.	%	%	Vol.	Ash	as rec'd
Coarse screenings	13,209	8.45	66.4	74.8	25.2	2,510
Fine screenings	34,775	22.30	54.7	80.2	19.8	3,760
Grits	98,549	63.20	54.5	52.1	47.9	2,700
Chaff	9,407	6.05	5.1	67.0	33.0	6,170
Total	155,940	100.00				
Weighted average			52.5	60.7	39.3	3,150

Discussion of
"SANITARY ENGINEERING PROGRAMS OF THE I.C.A.
IN THE N.E.A. AREA"

by V. B. Lamoureux
(Proc. Paper 885)

V. B. LAMOUREUX,[1] M. ASCE.—There is little to be said in reply to the discussions by A. Streiff (1003-21) and Kazuyoski Kawata (1048-15) of the original paper presented at the General Meeting of the ASCE in November, 1955. It is particularly a little difficult to comment from Montevideo where the author is now a sanitary engineering consultant on the staff of the U.S. Operations Mission to Uruguay.

Mr. Streiff has an enviable background of knowledge and experience in the Middle East and South Asia, the area to which the paper specifically referred. These experiences taught him, at the time when he was resident in these countries, how to protect himself and his family from those communicable diseases which were then prevalent. The pace then at which the populations were moving was slower and more measured. Diseases existed about which there was little knowledge of their transmission and their control. There was considerably less intercourse between countries and fewer travellers who could unwitingly be the carriers of disease from one country to another. Yet diseases must have been as prevalent then as now with less statistical knowledge or even interest in statistics to measure morbility and mortality. Death at an early age was accepted and because of disease the life-expectancy as of now in many of these countries has decreased to about 30 years against about 70 years in the U.S. today. Infant mortality has increased to around 400 per 1000 live births at the time that technical assistance was made available on such a broad scale. For many years, many of the foundations, notably the Rockefeller Foundation, had worked with considerable success but always on a limited scale because of limited funds in this area. They were not only able to point up the diseases which existed but develop methods of attacking them. They were able to demonstrate a lack of productivity on the part of a debilitated population and also to show that the improved health of a populated area contributed to increased productivity and income as well as improved health and living conditions. Increase in nutrition as well as improvement in health have made profound changes in these areas. The interest of the U.S., beyond attacking these diseases in their places of origin which may well be imported into the U.S. in these days of speedy transportation, has been to help these nations help themselves, to assist in the development of their resources and their manpower so that they may become self-sustaining and thus contribute to their own wealth and the wealth of the world. A healthy nation is a free-thinking nation, an asset to the community of nations and not a charge on the taxpayees of more fortunate countries. What has been invested by the U.S. taxpayer may well be returned in commerce between the U.S. and these countries.

1. San. Eng. Director, U.S. Public Health Service, Washington, D.C.

Mr. Kawata points out that travel from rural to urban areas already exists because of overpopulation and lack of opportunity in the rural areas. This is precisely the problem. Improvements to cities that are already crowded can but offer additional inducement to a rural population to increase its migration into these cities so that the problem of crowding in urban areas is never solved. Industrial development within these cities is an added incentive. Improved agriculture together with improvement within the villages through the addition of safe water supplies, proper excreta disposal, good drainage, better roads, better and larger educational facilities and the development of village industry can do much to retain village population and perhaps even reverse the trend toward the cities.

Technical assistance in these areas needs well-trained technicians in many fields other than in environmental sanitation and sanitary engineering. Whatever the causes of scarcity of technicians may be there are jobs to be done and the U.S. will continue to assist in whatever manner it may without any feeling on the part of the assisted countries that they are being subjected to any form of colonialism. Once they have trained technicians and training facilities of their own, the U.S. may well withdraw as rapidly or as gradually as may be necessary to assure continuance of a country-supported program.

Discussion of
"DESIGN OF VENTURI FLUMES AND CIRCULAR CONDUITS"

by Edwin A. Wells and Harold B. Gotaas
(Proc. Paper 928)

CORRECTIONS.—The photographs for Fig. 3 of this paper were inadvertently omitted. They are reproduced herewith on the following page.

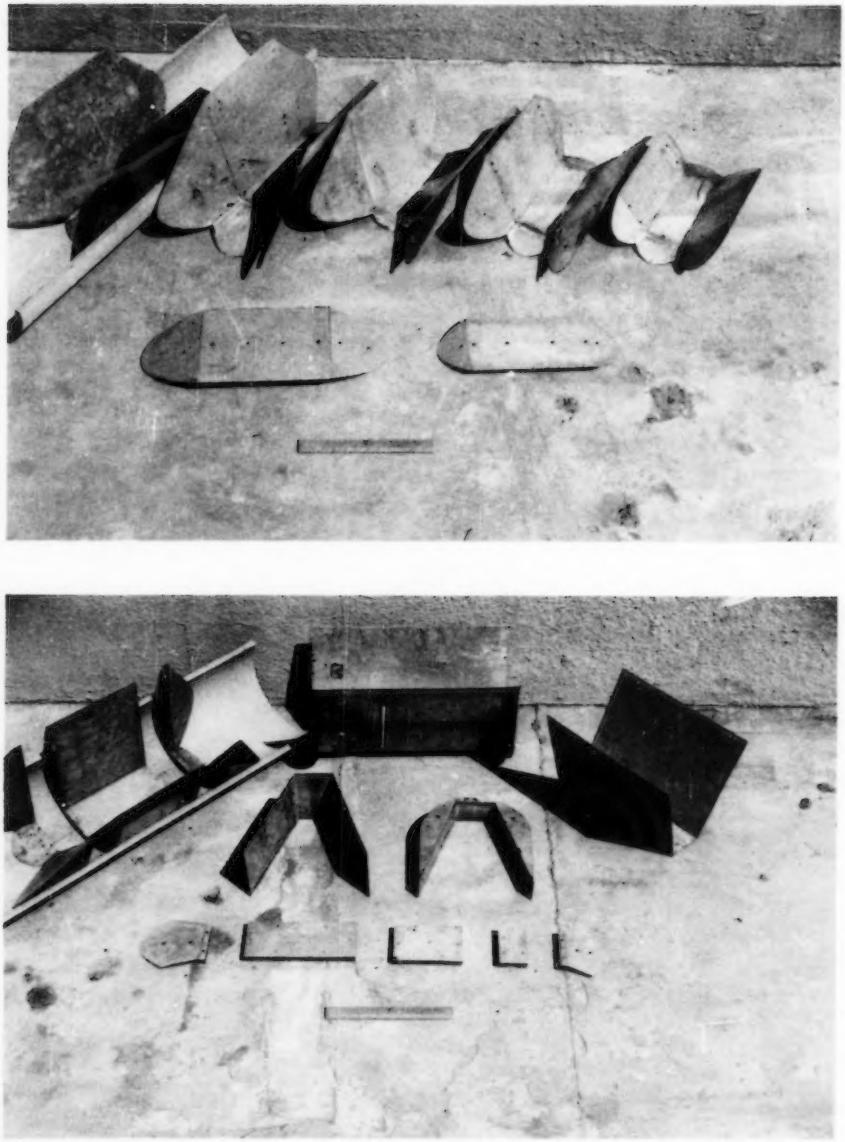


Fig. 3. The seven solid flumes tested are shown in the upper picture. Left to right, they are flumes 1 (in the bottom half of the bottom half of the tested channel), 8, 7, 3, and 4. In front are flumes 6 and 5. In the lower picture the parts for the erector series flumes are shown. Ten flumes of this type were tested. At the left, in the channel, are the components of flume 1c.

Discussion of
"USE OF SOIL LYSIMETERS IN WASTE WATER RECLAMATION STUDIES"

by Gerald T. Orlob and Robert G. Butler
(Proc. Paper 1002)

GERALD T. ORLOB,[1] and ROBERT G. BUTLER,[2] Junior Members, ASCE.—Use of soil lysimeters in waste water reclamation studies must, as Mr. Stone observes, be tempered with an appreciation of certain of their limitations. Results of such investigations are certainly not a complete substitute for a thorough engineering investigation of conditions at the proposed recharge site. They are valuable, however, in guiding the engineer in his preliminary investigations and can be employed at costs comparatively much lower than expenditures for development of the one-half-acre plots which Mr. Stone advocates.

The investigations presented in the paper as well as subsequent studies and observations of the field performance of spreading basins and storm water disposal sumps have demonstrated that infiltration of waste waters into soil is controlled by the surface stratum. For this reason it is of small consequence that the lysimeter medium is a disturbed specimen. The surface layer of soil on any field basin also has its basic structure altered in construction and operation of the basin.

Perimeter effects, i.e., the contribution to surface infiltration by unrestricted lateral flow, are most pronounced on small test plots and tend to diminish percentage-wise as the basin size is increased. These effects may be particularly significant when an impermeable sub-surface horizon exists. Under such circumstances surface spreading may not be a suitable water reclamation technique. In general, when the prototype basin is large, flow is predominantly vertical as in the soil lysimeter.

If lysimeter walls are constructed of corrugated steel, as were those used in the studies reported in this paper, short circuiting along the perimeter surface will be minimal. The danger of "piping" contaminated water through the medium is greatest near the onset of spreading on a previously dried soil but is rapidly minimized by intrusion of suspended matter. It should be noted that in the natural soil profile, also, root channels and media discontinuities exist which may aid bacterial penetration.

Soil gases at great depths are of comparatively small consequence in restricting percolation when compared to the intrusion of particulates into surface soil voids and the production of gases from biological stabilization of organic matter. These phenomena are confined to a comparatively shallow depth of medium and may be virtually the same in lysimeter as in prototype basins.

It is well to analyse the results of lysimeter studies critically before indulging in the expense of large scale test plots. A potentially promising spreading site may be proved less than feasible by a little inexpensive preliminary investigation.

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DIVISION ACTIVITIES

SANITARY ENGINEERING DIVISION

Proceedings of the American Society of Civil Engineers

NEWS

April, 1957

SANITARY ENGINEERS AND ACCIDENT PREVENTION

Eugene L. Lehr

Accident prevention has long been considered a specialized field. In industry, development of physical safeguards and safety practices has achieved a high degree of success under the professional guidance of safety engineers. The presently increasing public health acceptance of responsibility in the field of accident control makes it likely that sanitary engineers will in growing numbers be called upon to apply their proven skills to this important public health problem.

There is an increasing awareness that accidents are a major public health problem. They rank fourth as an over-all cause of death, and are now the first cause of death from ages one through thirty-four. In 1955, there were 93,000 deaths from accidents or one every six minutes. Of these deaths, 40 percent occurred as the result of motor vehicle accidents and 30 percent were due to home accidents.

Accidents, like typhoid fever, can be controlled. They are no more "Acts of God" than are outbreaks of cholera or yellow fever. With careful investigation, causes can be determined. This knowledge can then be used to develop methods of prevention and control.

The increasing acceptance of the accident problem as a public health challenge is evidenced by the fact that 17 State health departments have developed accident prevention activities as part of their over-all programs, and 21 additional State health departments have taken preliminary steps toward developing such activities. At the local level, there are 256 health departments undertaking accident prevention activities.

Sanitary engineers are assuming an important role in accident prevention and control. In the Public Health Service, an expanded accident prevention program, although under medical direction, has assigned a sanitary engineer to direct its program services. Since the environment is such an important factor in home accidents, this engineer is also responsible for integration of hygiene of housing activities into the accident prevention program.

In State health departments, sanitary engineers are usually responsible for the over-all direction of active accident prevention programs. In these programs, a particular effort is being made to study the nature and extent of the accident problem by the adaptation of epidemiological techniques, and to reduce the toll of accidents through the application of preventive measures.

Note: No. 1957-9 is part of the copyrighted Journal of the Sanitary Engineering Division of the American Society of Civil Engineers, Vol. 83, SA 2, April, 1957

At the local level, sanitary engineers in municipal health departments frequently assume leadership in accident prevention, particularly with respect to specialized aspects. In Denver a housing code regulating the sanitation and safety of occupied dwellings is administered by the Director of Environmental Sanitation of the City's Department of Health and Hospitals. Hazardous ceilings, dangerous stairways, and similar unsafe features are subject to orders for correction to the same extent as sanitation hazards. Even prior to adoption of the housing code, there had been an intensive campaign against faulty gas burning appliances in homes, which were causing a high number of casualties from carbon monoxide poisoning each year. In cooperation with other city departments and backed by a special ordinance, known or suspected cases of carbon monoxide poisoning were intensively investigated, causes determined, and faulty installations immediately sealed to prevent further use until corrected. Combined with an inspection program designed to disclose hazardous installations before they could cause serious accidents, this program has resulted in marked improvement.

As the fact that accidents are related to environmental conditions becomes more widely accepted, sanitary engineers will be called upon in increasing numbers to apply their knowledge and skill to the solution of problems in this field of public health. This is another illustration of the need for versatility on the part of the sanitary engineer. It also indicates a need for sanitary engineers to become more familiar with the problems and to prepare themselves to accept responsibilities in this field.

* * * *

SERIOUS LAG IN SANITATION SALARIES REPORTED

Problems of recruitment of qualified engineers and sanitarians by local health departments are reflected in the first of five reports by the Committee on Salaries of the Conference of Municipal Public Health Engineers.

Failure of health departments by substantial margins to pay the going price for competent personnel in environmental health services is resulting in a growing shortage, especially of engineers.

The Committee surveyed the salaries of engineers, sanitarians, sanitary inspectors, veterinarians, and other environmental health personnel in 371 full-time local health departments. In its report are shown the rise in salary levels from 1951 to 1956.

According to the report, salaries have been rising steadily at rates varying from 5 to 13 percent each year, but they fail to match those paid in similar professional categories outside of health departments.

Salaries for engineers are well below those paid to other members of the profession. In 1952-54, the median salary was $1000 below the median for county and municipal engineers and $2,400 below the median for all engineers. Under the circumstances, the number of vacant engineering positions in local health departments increased from 15.9 percent in 1951 to 23 percent today.

Starting salaries in local health agencies for engineers with no experience in 1956 ranged from $4,250 to $4,650. The same year engineering schools reported a median starting salary of $5,040 and predicted that their 1957 graduates will expect around $5,250. In addition to paying higher salaries, private employers tell the young engineer that his interview and moving expenses will be paid, that he will receive an annual bonus, overtime pay and free medical and hospital care.

While top salaries for sanitarians have been rising more rapidly since 1954 than for any other salary group, the median salary since 1952 has been $2000 or more below that of engineers in local health departments and approximately $750 below the median salary paid to male professional and technical workers in the United States.

Seven percent of the sanitarian positions studied were vacant. One-third of these were available to college graduates with no experience, offering a starting salary of $4,479. Vacant positions for sanitarians offer higher salaries than filled ones. Among 675 filled positions with the same requirements, the median starting salary was $4,347.

Members of the reporting Committee are: Walter A. Lyon, chairman, William T. Ballard, Herbert J. Dunsmore, Reinhart W. Koch, John W. Lemon, Eric W. Mood, Louis W. Pickles, Jack C. Rogers, and Lester A. Sanger.

Copies of the report may be obtained by writing to Walter A Lyon, Philadelphia Department of Public Health, Room 630, City Hall Annex, Philadelphia 7, Pennsylvania.

* * * *

PROFESSIONAL DEVELOPMENT

Sanitary engineers who are interested in professional development, as it affects them as individuals or the engineering organizations with which they are associated, will be interested in an article which appeared in the February issue of Industrial and Engineering Chemistry. In this article, entitled, "Developing Chemists and Chemical Engineers into Managers," Mr. T. S. Lisberger discusses the set of principles used as a basis for the philosophy and approach to the management development program adopted by the General Electric Company.

Though designed for management development, the principles evolved have direct application to the individual engineer and engineering administrators. These principles are summarized as follows:

Development is an individual process and each individual's own interests, attitudes, emotions, abilities, experience, desires, and inner drives must be taken into account.

All development is self-development and an engineering organization can present only the challenge and opportunity for an individual to develop himself.

The major part of an engineer's development occurs during his day-to-day work and his working environment must be conducive to such development. This means that an organizational structure must first be sound so that each person has a job clearly defined with definite responsibilities, accountabilities, and authorities. Professional growth requires that an engineer be given challenge and opportunity in which he can have full and frank communication with his supervisor. Objectives and goals should be clearly thought through, challenging, and well understood by all.

The opportunity for development must be universal with equal opportunities for all qualified individuals.

Every individual should have a full and appropriate opportunity to develop himself to his fullest capacity. The emphasis must be on development on a man's present job, not on the promotion ladder. When emphasis is placed on the promotion ladder, a man may easily come to believe that he is not in his present position for long, but will soon be moving on to the next rung of the

ladder. He feels that he is not on the job to make a contribution, but just to observe. A development plan which places a man in a certain position and then automatically moves him to the next position after a certain period of time is not beneficial to the individual or to the company involved. Promotion, when and if available, should only come to the individual who has truly earned it.

Decentralization of decision making is the prime instrument of development, because it provides the opportunity for full decision making experience.

A supervising engineer is personally responsible for developing himself and for aiding those engineers who report to him. One of the measures of a supervisor's performance should be how well he helps people to develop. Professional development is an individual thing and each person needs to work out with his supervisor his own program of self-development. This starts from a review of the man's performance in which both strengths and weaknesses are analyzed. A plan to build on strengths and to correct weaknesses is then developed.

Continuing education is a necessity. Because of the constant changes taking place in our technology, today's engineer must read and study continuously in order to keep abreast of latest developments if he is to make rather than merely meet the future.

* * * *

INDIANA WATER RESOURCES STUDY REPORT COMPLETED

The Indiana Water Resources Study Committee has completed its study of state water resources problems and water management laws—both surface and ground waters—authorized by the 1955 General Assembly and has submitted its report to the Governor and the 1957 General Assembly. Recommendations included:

1) A continuation of the study for another two years.
2) Authorization of a study by the Indiana University School of Law for the modernization and recodification of the drainage ditching laws.
3) Legislation by which natural resource conservancy districts may be created for the purpose of developing small watershed soil and water improvement projects; sewage and sewage treatment systems; recreational, forest and wildlife areas; and other proper projects.
4) Provision for state participation in financing USGS topographical mapping program on the same basis as during 1956 and 1957.
5) Provision of funds to the Indiana Flood Control and Water Resources Commission for cooperation with USGS on surface water investigations.
6) Provision of funds to the Indiana Department of Conservation for cooperation with USGS on ground water investigations and expansion of water well records.
7) Provision of registration of Indiana well drillers.
8) Expansion of certain activities and programs related to the Stream Pollution Control Board of Indiana, with provision that underground waters be made subject to pollution control.
9) Provision of funds and authorization for the Indiana Flood Control and Water Resources Commission to expand investigations and surveys on surface water resources in cooperation with the Corps of Engineers.

DID YOU KNOW THAT—

The By-laws of the American Sanitary Engineering Intersociety Board state "registered professional engineers who have had a minimum of 15 years of practice and have achieved a high standing in Sanitary Engineering may be excused from examination. For this certification without examination, application must be made on the prescribed form before July 1, 1957, and the full application, examination, and annual fees must be paid even though the examination is waived. Applicants of this category may be accepted by the Board in its judgment, whether or not they meet fully the eligibility and educational requirements previously listed."

"There will be no need to mark an application specifically for consideration of certification without examination. Each application received before July 1, 1957, will be considered in the light of the above provisions. If the candidate is deemed eligible for certification without examination, he will be so notified. If, on the other hand, he does not meet the special requirements, he will be notified of his admission to examination, or rejection, whichever applies."

In a recent action the American Institute of Chemical Engineers was accepted as a sponsor of the Intersociety Board. H. P. Munger, Department of Chemical Engineering, Syracuse University; K. S. Watson, General Electric Company, Schenectady, New York; and R. F. Weston of Weston, Eckenfelder, and Associates, Newtown Square, Pennsylvania, have been nominated for Board membership.

* * * *

Title I of the Health Amendments Act of 1956 authorizes the Public Health Service to establish a program of traineeships for graduate or specialized public health training for professional health personnel, such as physicians, nurses, sanitary engineers, nutritionists, medical social workers, dentists, health educators, veterinarians, sanitarians, and others whose professional skills are required in modern public health practice.

The primary objective of this program is to bring new people into the field of public health through providing postgraduate training opportunities for men and women who have completed their basic professional education.

An individual may select the educational institution of his choice which offers a nationally recognized graduate or specialized public health training program in his professional field. It is the responsibility of the individual to make all the necessary arrangements with the training institution. This means that an individual desiring a public health traineeship must be found acceptable for training by the institution before his application can be considered by the Public Health Service.

* * * *

Black and Veatch, Consulting Engineers of Kansas City, Missouri, have moved and consolidated their offices, now being located at 1500 Meadow Lake Parkway, Kansas City, Missouri. The new building was recently inspected by a large group of members of the engineering profession at a buffet-cocktail open house.

* * * *

At the request of the Government of India, John M. Henderson, Deputy Chief, Technical Development Laboratories, Public Health Service, Savannah,

Georgia, left for that country in January to spend three months as a member of a three-man international team to evaluate the national malaria control program and prospects for malaria eradication.

* * * *

Prof. William T. Ingram of New York University has been named director of a project to study the problem of "fogged-in" and "smogged-in" airports. The project was announced by New York University's Engineering Research Division and the Flight Safety Foundation, the sponsoring agency.

* * * *

The Sixth Southern Municipal and Industrial Waste Conference was held in the new College Union Building on the campus of North Carolina State College, Raleigh, N. C., on April 1 and 2.

This year's conference highlighted conservation measures as a means of controlling stream pollution. The keynote speaker was Oregon's Senator Wayne Morse who spoke on water conservation measures.

The annual conferences are sponsored jointly by Duke University, the University of North Carolina, and North Carolina State College. They have as their objective the bringing together of administrators of municipalities, industries, and governmental agencies to delineate their respective responsibilities in pollution abatement.

* * * *

Dr. Charles-Edward A. Winslow, Professor Emeritus of Public Health at Yale University, died January 8 in New Haven, Conn. at the age of 79.

Dr. Winslow founded the Department of Public Health at Yale in 1915 and served as its chairman until his retirement in 1945. He had been a Yale faculty member for 30 years.

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John M. Henderson and John S. Wiley, Technical Development Laboratories, Public Health Service, Savannah, Georgia, were elected President and Secretary-Treasurer of the Savannah Branch, ASCE, for 1957.

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New Mexico A & M moved into their new engineering building February 1. The building contains a sanitary engineering laboratory complete with new fixtures and equipment.

* * * *

The newly formed New Mexico Water and Sewage Works Association, Bob Lowe, President (AM-ASCE) is gaining new members steadily. A Southwest Section of the New Mexico Water and Sewage Works Association has been formed with M. H. Alexander, President. Monthly meetings are being held.

The principal purpose of the new organization is to promote the New Mexico Water and Sewage Short School, J. W. Clark, general chairman (AM-ASCE) and work towards certification of operators.

* * * *

Marshall P. Crabill, Assoc. Member ASCE, and vice president in charge of operations of the Indianapolis Water Company, was nominated for the

George Warren Fuller Award by the Indiana Section of AWWA at its annual meeting in Indianapolis on February 8, 1957.

It is also worthy of note that Lewis S. Finch, Member, ASCE, and vice president and chief engineer of the Indianapolis Water Company, is the new vice president-elect of the AWWA. When Mr. Finch assumes the president's chair, he will be the fourth president from the Indianapolis Water Company. This contribution from a single water utility is a record to be proud of.

* * * *

Charles A. Haskins, SED member and Member ASCE, passed away suddenly on December 28, 1956. Mr. Haskins, at 69, was head of the Engineering Firm of Haskins, Riddle and Sharp in Kansas City, Mo.

* * * *

DID YOU KNOW THAT—

Two SED Members, L. M. Fisher and A. H. Wieters, were awarded ASCE life membership diplomas at the National Capital Section Annual Dinner, February 12, in Washington, D.C.

Mr. Fisher received his Civil Engineering degree from Pennsylvania State University. He began his technical career with the Coast and Geodetic Survey working in Maine, Alaska, and the Philippines on chart revision and mapping. In 1912 he joined the Bureau of Health for the Philippine Islands to practice his specialty, sanitary engineering. From 1918 to 1950 he served as District Engineer, Public Health Service, at Washington, New York, Chicago, and in the Surgeon General's office. He was in the first group of sanitary engineers to be commissioned in the regular corps of the Public Health Service in 1930. He served for three years as Engineering Field Associate with the American Public Health Association and in a consulting capacity to World Health Organization, Geneva, Switzerland, on sanitation problems. In 1955 he served for a year as Director, Interstate Commission on the Potomac River Basin and is still a member of this Commission. Mr. Fisher is a Registered Professional Engineer, and in private practice.

Mr. Wieters received his Civil Engineering degree from the University of Kansas and a M.S. degree in Sanitary Engineering from Harvard University. He began his technical career with the firm of Black and Veatch in Kansas City, Missouri, in 1919, after service as a commissioned officer in World War I. He was Asst. Engineer, Kansas State Board of Health from 1919 to 1921. He joined the South Dakota State Board of Health as Director of Sanitary Engineering; and later the Iowa State Department of Health as Director of Sanitary Engineering and Industrial Hygiene. In 1946 he joined the Public Health Service as Assistant Chief of the Water Pollution Control Division. In 1955 he became Consultant to the Brazilian Ministry of Health, a position he now holds. Mr. Wiethers is a past President of the Iowa Engineering Society; Life Member of the American Water Works Association; a Fellow of the American Public Health Association; and past Chairman of its Sanitary Engineering Section. He is also past Chairman of the Sanitary Engineering Division of ASCE.

* * * *

The Kansas City Section of ASCE will be headed for the coming year by a SED member, W. G. Riddle. Other officers for the 1957 year who are SED

members include L. M. Bremser, as Secy-Treasurer; and R. O. Davis, Director. Mr. Riddle has also been elected chairman of the Board of Directors of the Kansas City Engineers Club.

* * * *

The Public Health Service awarded 104 research grants totaling $1,464,881 in the last six months of 1956 to support research studies in water pollution, water supply, and air pollution.

Of the 104 grants, 74, totaling $713,972, are for research in water supply and water pollution. Thirty-six of the grants are for new projects, and 38 are for the continued support of projects already under way. These research grants include awards to investigators working in 43 institutions in 27 States and the District of Columbia.

The remaining 30 grants, totaling $750,909, are for research in problems of community air pollution. Twenty of the grants are for new projects, and 10 are for the continued support of projects now in progress. These research grants were distributed among investigators located in 24 institutions in 14 States.

* * * *

SED Members are proud in the knowledge that one of their group, Garvin H. Dyer, Director of the Missouri Water Company and Manager of the Independence Division, is the President-Elect of the National Society of Professional Engineers. Mr. Dyer is an honor member of Chi Epsilon and a past president of the Mid-Missouri Section of the ASCE.

* * * *

The Missouri Water Pollution Control legislative program is moving forward in that a bill sponsored by informed and responsible persons and groups is presently in the hands of a Senate Committee. The third of three hearings will be held shortly, and passage of the bill appears likely.

* * * *

Did you know that bees may have a bearing on sewage disposal?

The Purdue University "Sanitary Engineering News" reports a complaint made by an Association of Beekeepers against the spraying of sewage as an artificial rain in areas where bees are numerous. The complaint states that bees flying through the polluted spray become contaminated with pathogenic organisms which in turn can be transferred to human blood by stings.

* * * *

There are two finishes for automobiles—liquor and lacquer.

* * * *

The Cincinnati Sewage Disposal Section reports considerable progress in the elimination of prohibitive industrial wastes discharged to streams of the Cincinnati Metropolitan Area. Reductions of 83% BOD, 94% suspended solids and 83% ether soluble matter (based upon poundage) were accomplished in the 28 months since the Cincinnati Industrial Waste Ordinance was enacted in 1953. The reductions are the result of the cooperation between the Ohio Water Pollution Control Board, industry, and the City of Cincinnati.

* * * *

DID YOU KNOW THAT—

E. J. Cleary, Executive Director of the Ohio River Valley Water Sanitation Commission, is serving as a consultant in the evaluation of a water resources planning seminar program at the Harvard University Graduate School of Public Administration. This three-year program, financed with a grant from the Rockefeller Foundation, combines for the first time at Harvard the participation of both the Engineering Faculty and students with those from the Social Sciences in what is known as "Public Policy Seminars."

* * * *

Francis W. Montanari, a sanitary engineer associated with the Institute of Inter-American Affairs for the past 11 years, has been appointed to the staff of the Ohio River Valley Water Sanitation Commission. Mr. Montanari comes to the Commission from Panama where he acted as consultant on sanitary installations sponsored by the Point Four Technical Assistance Program in Latin America.

* * * *

Robert R. Harris has been appointed chief of the sewage treatment plant construction grant program authorized by the new Federal Water Pollution Control Act. Mr. Harris replaces Curtiss M. Everts, Portland, Oregon, who directed the early stages of the Federal-aid program to help communities build sewage treatment works.

As of February 25, the Public Health Service had approved 83 municipal sewage treatment works, with an estimated total cost of $23,072,107 and a Federal contribution of $5,422,262.

Formerly associate chief engineer of the Kentucky State Health Department, Mr. Harris joined the Public Health Service in 1948. He was assigned to the Pacific Northwest Drainage Basin Office in Portland. In 1955 he was transferred to Washington as chief of the Water Pollution Control Program's water supply section.

* * * *

The first public hearing on interstate water pollution under the Federal Water Pollution Control Program was held at Homer, Louisiana, January 16 and 17, 1957.

Involved are the waters of the Corney Drainage system flowing from Arkansas into Louisiana's 1940-acre Corney Lake, a part of the Claiborne Parish Land Utilization recreational project.

On the basis of investigation by the Public Health Service, findings of pollution of these interstate waters were made by the Surgeon General.

The Hearing Board found that prior to the oil well discharges the Corney Creek waters "were extensively used by the public and private individuals for sport and commercial fishing, recreation, and other beneficial uses."

Discharge of the oil wastes, the Board found, made the Corney system unfit for these purposes and if the discharge continued, the Board found, it would also impair the usefulness of the 15,000-acre proposed Lake d'Arbonne, in Louisiana, for which appropriations were made by the Louisiana Legislature in 1956.

Upon recommendation of the Hearing Board, the Secretary of Health, Education, and Welfare has notified five oil well operators that "a properly

constructed, operated, and maintained collection and injection system is a reasonable and equitable method of securing abatement of the pollution of Corney Drainage System," and that action should be taken immediately to abate pollution.

Members of the hearing Board were:

Chester S. Wilson, Stillwater, Minnesota, Chairman, lawyer and former Conservation Commissioner of Minnesota; Kenneth E. Biglane, Baton Rouge, La.; Executive Secretary of the Louisiana Stream Control Commission; Harold C. Jackson, New Orleans, representing the U.S. Department of Commerce; Glen T. Kellogg, Little Rock, representing the Arkansas Water Pollution Control Commission; and Blucher A. Poole, Indianapolis, Chief Engineer of Indiana's Stream Pollution Control Board.

* * * *

Ralph H. Holtje, formerly chief of the Water Pollution Control Section of Indiana State Board of Health's Division of Sanitary Engineering, has recently accepted a position with the USPHS. Mr. Holtje is assigned to the Water Pollution Control activities within the Division of Sanitary Engineering Services.

Please cooperate by sending news items of interest to:

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PROCEEDINGS PAPERS

The technical papers published in the past year are identified by number below. Technical-division sponsorship is indicated by an abbreviation at the end of each Paper Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways and Harbors (WW) divisions. Papers sponsored by the Board of Direction are identified by the symbols (BD). For titles and order coupons, refer to the appropriate issue of "Civil Engineering." Beginning with Volume 82 (January 1956) papers were published in Journals of the various Technical Divisions. To locate papers in the Journals, the symbols after the paper numbers are followed by a numeral designating the issue of a particular Journal in which the paper appeared. For example, Paper 1113 is identified as 1113 (HY6) which indicates that the paper is contained in the sixth issue of the Journal of the Hydraulics Division during 1956.

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APRIL: 925(WW2), 926(WW2), 927(WW2), 928(SA2), 929(SA2), 930(SA2), 931(SA2), 932(SA2)[c], 933(SM2), 934(SM2), 935(WW2), 936(WW2), 937(WW2), 938(WW2), 939(WW2), 940(SM2), 941 (SM2), 942(SM2)[c], 943(EM2), 944(EM2), 945(EM2), 946(EM2)[c], 947(PO2), 948(PO2), 949(PO2), 950(PO2), 951(PO2), 952(PO2)[c], 953(HY2), 954(HY2), 955(HY2)[c], 956(HY2), 957(HY2), 958 (SA2), 959(PO2), 960(PO2).

MAY: 961(IR2), 962(IR2), 963(CP2), 964(CP2), 965(WW3), 966(WW3), 967(WW3), 968(WW3), 969 (WW3), 970(ST3), 971(ST3), 972(ST3)[c], 973(ST3), 974(ST3), 975(WW3), 976(WW3), 977(IR2), 978(AT2), 979(AT2), 980(AT2), 981(IR2), 982(IR2)[c], 983(HW2), 984(HW2), 985(HW2)[c], 986(ST3), 987(AT2), 988(CP2), 989(AT2).

JUNE: 990(PO3), 991(PO3), 992(PO3), 993(PO3), 994(PO3), 995(PO3), 996(PO3), 997(PO3), 998 (SA3), 999(SA3), 1000(SA3), 1001(SA3), 1002(SA3), 1003(SA3)[c], 1004(HY3), 1005(HY3), 1006 (HY3), 1007(HY3), 1008 (HY3), 1009 (HY3), 1010 (HY3)[c], 1011 (PO3)[c], 1012 (SA3), 1013 (SA3), 1014(SA3), 1015(HY3), 1016(SA3), 1017(PO3), 1018(PO3).

JULY: 1019(ST4), 1020(ST4), 1021(ST4), 1022(ST4), 1023 (ST4), 1024(ST4)[c], 1025(SM3), 1026 (SM3), 1027(SM3), 1028(SM3)[c], 1029(EM3), 1030(EM3), 1031(EM3), 1032(EM3), 1033(EM3)[c].

AUGUST: 1034(HY4), 1035(HY4), 1036(HY4), 1037(HY4), 1038(HY4), 1039(HY4), 1040(HY4), 1041(HY4)[c], 1042(PO4), 1043(PO4), 1044(PO4), 1045(PO4), 1046(PO4)[c], 1047(SA4), 1048 (SA4)[c], 1049(SA4), 1050(SA4), 1051(SA4), 1052(HY4), 1053(SA4).

SEPTEMBER: 1054(ST5), 1055(ST5), 1056(ST5), 1057(ST5), 1058(ST5), 1059(WW4), 1060(WW4), 1061(WW4), 1062(WW4), 1063(WW4), 1064(SU2), 1065(SU2), 1066(SU2)[c], 1067(ST5)[c], 1068 (WW4)[c], 1069(WW4).

OCTOBER: 1070(EM4), 1071(EM4), 1072(EM4), 1073(EM4), 1074(HW3), 1075(HW3), 1076(HW3), 1077(HY5), 1078(SA5), 1079(SM4), 1080(SM4), 1081(SM4), 1082(HY5), 1083(SA5), 1084(SA5), 1085(SA5), 1086(PO5), 1087(SA5), 1088(SA5), 1089(SA5), 1090(HW3), 1091(EM4)[c], 1092 (HY5)[c], 1093(HW3)[c], 1094(PO5)[c], 1095(SM4)[c].

NOVEMBER: 1096(ST6), 1097(ST6), 1098(ST6), 1099(ST6), 1100(ST6), 1101(ST6), 1102(IR3), 1103 (IR3), 1104(IR3), 1105(IR3), 1106(ST6), 1107(ST6), 1108(ST6), 1109(AT3), 1110(AT3)[c], 1111(IR3)[c], 1112(ST6)[c].

DECEMBER: 1113(HY6), 1114(HY6), 1115(SA6), 1116(SA6), 1117(SU3), 1118(SU3), 1119(WW5), 1120(WW5), 1121(WW5), 1122(WW5), 1123(WW5), 1124(WW5)[c], 1125(BD1)[c], 1126(SA6), 1127 (SA6), 1128(WW5), 1129(SA6)[c], 1130(PO6)[c], 1131(HY6)[c], 1132(PO6), 1133(PO6), 1134(PO6), 1135(BD1).

VOLUME 83 (1957)

JANUARY: 1136(CP1), 1137(CP1), 1138(EM1), 1139(EM1), 1140(EM1), 1141(EM1), 1142(SM1), 1143(SM1), 1144(SM1), 1145(SM1), 1146(ST1), 1147(ST1), 1148(ST1), 1149(ST1), 1150(ST1), 1151(ST1), 1152(CP1)[c], 1153(HW1), 1154(EM1)[c], 1155(SM1)[c], 1156(ST1)[c], 1157(EM1), 1158 (EM1), 1159(SM1), 1160(SM1), 1161(SM1).

FEBRUARY: 1162(HY1), 1163(HY1), 1164(HY1), 1165(HY1), 1166(HY1), 1167(HY1), 1168(SA1), 1169(SA1), 1170(SA1), 1171(SA1), 1172(SA1), 1173(SA1), 1174(SA1), 1175(SA1), 1176(SA1), 1177(HY1)[c], 1178(SA1), 1179(SA1), 1180(SA1), 1181(SA1), 1182(PO1), 1183(PO1), 1184(PO1), 1185(PO1)[c].

MARCH: 1186(ST2), 1187(ST2), 1188(ST2), 1189(ST2), 1190(ST2), 1191(ST2), 1192(ST2)[c], 1193 (PL1), 1194(PL1), 1195(PL1).

APRIL: 1196(EM2), 1197(HY2), 1198(HY2), 1199(HY2), 1200(HY2), 1201(HY2), 1202(HY2), 1203 (SA2), 1204(SM2), 1205(SM2), 1206(SM2), 1207(SM2), 1208(WW1), 1209(WW1), 1210(WW1), 1211(WW1), 1212(EM2), 1213(EM2), 1214(EM2), 1215(PO2), 1216(PO2), 1217(PO2), 1218 (SA2), 1219(SA2), 1220(SA2), 1221(SA2), 1222(SA2), 1223(SA2), 1224(SA2), 1225(PO)[c], 1226 (WW1)[c], 1227(SA2)[c], 1228(SM2)[c], 1229(EM2)[c], 1230(HY2)[c].

c. Discussion of several papers, grouped by Divisions.

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